VOL. 26 No. 2

BULLETIN

OF THE

TORREY BOTANICAL CLUB

FEBRUARY 1899

The primary Synthesis of Proteids in Plants

BY W. M. KOZLOWSKI

Our knowledge concerning the primary products of carbon synthesis and the formation of carbohydrates in plants is in a degree exact,* but regarding the question of synthesis of proteids we are not in a position to give any plausible reasons for our suppositions. This is not strange, when we consider that the very product of this synthesis is imperfectly known and that until recently we have had no rational nor even empirical formula of proteids which we could assume with any degree of probability.

I believe that little worthy of note will be omitted if I divide into four classes the views set forth in the scientific literature upon the structure of proteids.

1. Hunt considered these as nitryls of sugar, derived from the latter and ammonia, a supposition which can hardly be reconciled with the recent results of physiological and chemical investigations.

2. Sachsse holds that they are anhydrides produced from asparagin and from fatty aldehydes.

3. According to Schützenberger they are composed of ureids, derivatives of carbamide.

4. Finally, Grimaux, in his definition of proteids as compounds which by addition of water are decomposed into carbonic

*The author has shown in a Polish paper (Wezechswiat, 1893, Nos. 4 and 5) that the recent discoveries of E. Fischer make equally plausible three suppositions about the formation of carbohydrates from CO_2 and H_2O in plants; one of them is the well-known hypothesis of Bayer, the second was proposed by E. Fischer himself and the third by the author of the quoted paper.

[Issued February 8.]

acid, ammoniac and amidic acids, places them in the nearest vicinity with uric acid, which gives also by hydrolysis carbonic acid, ammoniac acid, glycocol.

The principal facts to be accounted for with these different hypotheses are the following:

1. The last product containing nitrogen in the metamorphosis of animals is carbamide or uric acid.

2. The compounds from which proteids are formed in plants, as will be shown later on, are most probably amides (including amidic acids and their amides, and especially asparagin) and the carbohydrates.

3. The products of decomposition of proteids under the action of pure chemical agents. These are in the most part amides which are obtained by the action of bromine,* of barium hydrate under high pressure,† of hydrochloric acid and stannous chloride,‡ by long boiling with sulphuric acid,§ or acids in greater part from the fatty series, obtained through the action of manganese dioxide and sulphuric acid ‖ as well as chromic acid.¶ Besides carbonic acid and oxalic acid are nearly always formed.

The presence of hippuric acid in the urine of herbivorous animals, the indol and the skatol found in the products of pancreatic digestion (Salkowski), the tyrosin nearly always present in the animal body, lead to the supposition that aromatic groups are also constituents of the proteid-molecule and it even seems that some of the most characteristic color reactions of these compounds are due to them.**

We shall not pass over in silence the synthesis of colloidal bodies obtained by Grimaux and by Schützenberger, which shows a very great resemblance to proteids. Grimaux obtained his colloid by melting together asparagic anhydride with carbamide; Schützenberger by the action of epichlorhydrin upon carbamide.

---

* Hasiwetz and Habermann, Liebig's Annalen, **159**: 304.

† Schützenberger, Annales de Chimie et de Physique, V. **16**: 289.

‡ Hasiwetz and Habermann, Lieb. Ann. **169**: 150.

§ Kreusler, Zeitschrift für Chemie, 1870: 93.

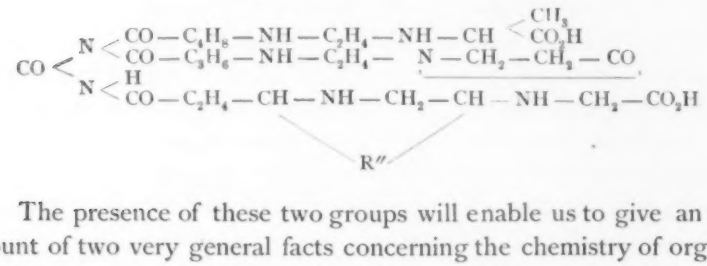
‖ Guckelberger, Liebig's Annalen, **64**: 39.

¶ *Ibidem.*

** So the reaction upon krautoprotein, by Millon and Liebermann. See Würtz. Second supplement au Dictionnaire de Chemie, 1892.

Taking into consideration the qualitative and quantitative relations of compounds derived from the proteids through the action of baryta-water under high temperature (200° C.) and pressure, Schützenberger * gives formulae for albumin and gelatin, which are perhaps premature as to minute details, but no doubt give quite an adequate expression of the fundamental facts both physiological and chemical by putting at the base of the proteid molecule, two groups, the carbamide and the oxamide:

$$CO < \begin{matrix} N = \\ N = \end{matrix} \text{ and } C_2O_2 < \begin{matrix} N = \\ N = \end{matrix} \dagger$$



The presence of these two groups will enable us to give an account of two very general facts concerning the chemistry of organization.

This is practically all that we know about the final product of synthesis of nitrogen compounds in plants. We shall take next into consideration the physiological facts elucidating that synthesis.

In the first place may be noted the changes of proteids in the germination of seeds. As colloids, they cannot be transferred from cell to cell unless they are decomposed into simpler crystalline bodies. A long series of investigations has shown that this transfer is performed in the shape of amides.

Asparagin is to be found in very many sprouting plants while it is not present in their seeds. Asparagin is not soluble in alcohol and when sections of plants are placed in that liquid it is deposited in characteristic crystals. By means of this reaction Pfeffer has shown that many seedlings contain asparagin, whether growing in light or in darkness; in other plants it is not present. This asparagin is obviously derived from the proteids contained in

* See the article of that author in the second supplement to the Dictionnaire de Chemie of Würtz (1892).

† We quote here the condensed formula of Schützenberger, given by Goutier in his Chimie de la cellule vivantem, 1895:

the seed and is used to build up the protoplasm of growing parts, as shown by the experiments of Boussingault and recently it has been confirmed by Laskowski, Fleury and Detmer, that when a seedling does not receive nitrogen from outside, the quantity of that element is not changed during the germination. In other words the plant does not lose its nitrogen.

In the same conditions as sprouting seeds are the young buds of plants ; their tissues are formed from the plastic materials gathered by the plant during the foregoing summer. Thus Borodin found asparagin and sometimes tyrosin in the buds of many trees and shrubs, especially in those which are developed from twigs cut in winter and grown in dull light, indicating that light impedes directly the formation of asparagin : but Pfeffer obtained the same result when cultivating lupine in light, but in an atmosphere free from carbonic acid. Such plants were very rich in asparagin.

There is, moreover, no doubt that the accumulation of asparagin is connected with another fact, the lack of carbohydrates. In the described experiments this was due either to the cutting off of a twig (freed of leaves and thus unable to assimilate) from a tree, containing reserve carbohydrates, or to the suspension of assimilation through darkness or lack of carbonic acid. In plants, which are growing in normal conditions, the asparagin does not accumulate, for it is at once combined with the produced carbohydrates to form proteids. This inference is confirmed by the investigations of Schultze and Uhrich,* who found that the large part (34–47.7%) of nitrogen in the roots of the beet (*Beta vulgaris*) is contained in amides (specially in glutamin and asparagin), while during the growth of the leaves a large portion of these bodies is consumed to form the proteids for these organs.

Emmerling gives as the result of the first of a series of investigations, which he undertook in this line on a large scale, the following statement : "The parts of plants growing energetically contain more amide than parts which are older and already developed." †

At last experiments with seeds growing in darkness complete

* Landwirtschaftliche Versuchsstationen, **18** : (1875) and **20** : (1877).

† Landw. Versuchsstationen, **24** : 153. 1880.

the preceding tests, showing that in this case amides and carbohydrates are produced from proteids. In the experiments of Uhrich, Schultz and Umlauf with seeds of lupine the result was that the plants cultivated in darkness contained 18.22% more of asparagin and 12.31% more of other amides and organic nitrogen compounds, while only 5.33% more of carbohydrates in form of glucose and cellulose than seeds ; on the other hand they contained 30.07% less of proteids. The comparatively slight increase of carbohydrates is explained by their loss from respiration, the general loss being 18.30% of dry substance.*

All these facts prove without doubt that amides can be produced in plants from proteids, and can, together with carbohydrates, be used in their reconstruction ; they do not of course prove that we can consider amides as the predecessors of proteids when formed from inorganic substances, and the difficulty of the investigation in this line is based upon the fact that amides are always found in growing plants as the form in which proteids are transported either to the young growing parts (as buds, flowers, fruits) or to places where they are deposited as reserve food for the next year (roots, bulbs, etc.).

In order to answer this question A. Emmerling† undertook a long series of investigations, consisting of the quantitative determination of different compounds of nitrogen in different parts of plants and in various stages of their growth. These investigations led him to the belief that amides are products, preceding the formation of proteids from inorganic substances in plants.

Before this series was completed (1887) other pieces of work appeared which tend to show the same results.

Kellner was the first who tried to ascertain that proteids are formed from amides. He compared the amount of amides in plants supplied with pure water and those supplied with a solution of potassic nitrate.‡ His results were criticised by E. Schultze § chiefly on the ground that we cannot consider amides as products

* Landwirtsch. Jahrbücher, **5** : (1876). The loss of dry substance is at the expense of fat (5.61%) and dextrine-like carbohydrates (10.02%), besides some other not fully explained substances.

† Landw. Versuchsstationen, **24** : 153 and foll. (1880).

‡ Landwirtschaftliche Jahrbücher, **8** : Suppl. 243. 1879.

§ Landw. Jahrbücher, **9** : (1880).

of the synthesis of inorganic substances, until we have proved that they are not produced from decomposition of proteids. In the meantime Hornberger and Raumer * applied the method of determination of proteids newly introduced by Stuzer. This method enables us to determine the amount of these bodies from other nitrogen compounds in plants. From the distribution of proteids and other nitrogen compounds in Indian corn, Hornberger and Raumer deduced that the amides in plants are not only derivatives of proteids, but also their predecessors produced synthetically.

This result was confirmed by Hornberger,† who experimented upon *Sinapis alba* and by Emmerling who had then completed his long series of experiments.‡

On the other hand a recent publication gives a support for the second part of the supposition concerning the amides as a link between inorganic bodies and proteids. Barthold Hansteen cultivated *Lemna* in solutions of asparagin and glucose in darkness and found an obvious increase of proteids. The same result was obtained with carbamide and cane sugar as well as with salts of ammonia (ammonium chloride and sulphate) while leucin, cretin and alanin showed themselves unable to serve as proteid-producing materials.§ The last observation concerning salts of ammonium if proved to be true cannot be generalized, for experiments made under the most stringent conditions have proved that phanerogamic plants cannot use ammoniacal salts as a source of nitrogen, although that capacity is possessed by fungi.

So regarding the metamorphsis of nitrogen in plants we know that by the oxidation of the nitrates of the soil it is transformed into reduced nitrogen of amides, which by combination with carbohydrates produce proteids.

We, therefore, have to answer two questions:

1. In what organs of the plant does this transformation or its particular phases take place?

2. What compounds are intermediate between nitric acid and

* Landw. Jahrbücher, **11**: (1882).

† Landw. Versuchsstationen, **32**: 415. 1885.

‡ Landw. Versuchsstationen, **34**: (1887).

§ Beiträge sur Kenntniss der Eiweissbildung in phanerogamen Pflanzen. Berichte deutsch. bot. Ges. **14**: 362. 1896.

the amides on the one hand, and between the latter and proteids on the other?

The first can be answered with greater certainty owing to the investigation of the past few years. As to the second—it can be answered only hypothetically; but as every experimental science is in the same degree dependent upon facts, and upon scientific ideas, and as observation or experiment is always guided by scientific hypothesis, we ought not to throw aside suppositions which can be induced from facts and are not at variance with the general spirit of scientific thought.

As to organs in which proteids are produced a supposition was given as long ago as 1862 by Sachs,* who considered the leaves as active in this process, Hanstein was led to the same results by his experiments in girdling shoots, and Pfeffer showed that the development of blossoms and buds is dependent upon the presence of leaves and the supply of the substance which circulates in the sieve tubes.

The same conclusion must be drawn from the above quoted investigations concerning the distribution of nitrogen compounds in plants. The general result is that the organic nitrogen compounds are accumulated in leaves until the latter reach their full development, then they decrease in order to be transferred into fruits and finally disappear from the stem and the leaves while they are still increasing in the fruits even if the plant is not supplied with nitrogen from outside.

But quite decisive are the investigations of A. F. W. Schimper,† who showed by means of the reaction with diphenylamin that the nitrates pass as such through the fibro-vascular bundle of leaves and disappear in the chlorophylic cells of the mesophyl while large amounts of calcium oxalate is produced, the calcium being combined with the nitric acid as calcium nitrate entering the plant through the roots. This disappearance occurs only in light, while in darkness or in leaves free from chlorophyl the nitrates are accumulated in large amount. The experiments of Schimper and many others make it probable that in the same way sulphites and

* Botanische Zeitung, and the articles scattered through the 45 vols. of Flora (1862 *seq.*) where the cribrose vessels are indicated as the place of formation of proteids.

† Bot. Zeitung, 1888, N. N. 5–10.

phosphites are decomposed in the leaves while the sulphur and phosphorus are used for building up the proteid molecules.

We cannot however agree with the conclusion of the author that the chlorophyl grain is the organ of this synthesis, and that the last is produced only under the influence of light. The synthesis of proteids from sugar and nitrates or salts of ammonia in fungi deprived of chlorophyl contradicts such a supposition. This objection cannot be overthrown by the single remark, that the assimilation of nitrogen is in some regard different from this process in higher plants, for we have no reason to admit the necessity of light and chlorophyl to the production of proteids, since we know that such a synthesis can be produced without their influence. Of course the principal difference between fungi and chlorophyl-bearing plants does not consist in the fact that they produce proteids in different ways, but that one of the compounds necessary to that production (the carbohydrates) is taken from the outside.*

More probable is the supposition, that to the reduction of nitrates into amides or to the consequent transformation of amides into proteids some compounds or groups of atoms are necessary which are produced during the assimilation of carbon and constitute perhaps some stage in the synthesis of carbohydrates. In fungi such bodies could be produced by a retrogressive metamorphosis from carbohydrates, and the energy developed by this reaction may be used for the process of synthesis of proteids. Such a supposition is supported by the fact observed by the same author viz.: the presence of some reducing substance in the chlorophyl-bearing cells which hindered in many cases the color reaction with the diphenylamin, while neither the glucose nor the starch produce such effect.†

In this connection may be mentioned the hypothesis of Löw advanced long before the publication of the work of Schimper,‡ and

* Since this was written two pieces of work have appeared which have overthrown by experience the above exposed view of Schimper, previously advanced by Osc. Müller (Landw. Versuchsst., 1887). The one is of Kinoshita (Bulletin of Agricultural College in Tokio, 1895 : 2), the other the above quoted memoir of B. Hansteen (Berichte deutsche bot. Ges. 1896).

† l. c., 145.

‡ Eine Hypothese über die Bildung des Albumins in Pflüger's Archiv, **22**: 503. 1880.

based upon facts concerning the feeding of fungi. By studying experiments (especially those of Pasteur and Nägeli) to determine whether compounds with or without nitrogen can feed fungi Löw found that only the compounds containing the group CH.OH are able to produce proteids.

He supposes then, that this reaction is performed in three phases:

The first consists in the production of asparagin aldehyde from the form aldehyde

$$\overset{\text{Form aldehyde.}}{4CH.OH} + NH_3 = \overset{\text{Asparagin aldehyde.}}{\begin{matrix} NH_2.CH.COH \\ | \\ CH_2.COH \end{matrix}} + 2H_2O$$

The second is the condensation of several molecules of asparagin aldehyde into a body now unknown.

$$3\left\{\begin{matrix} H_2N.CH.COH \\ CH_2COH \end{matrix}\right\} = \overset{\text{The unknown body.}}{C_{12}H_{17}N_3O_4} + 2H_2O$$

Löw maintains that this body is produced by the destruction of two or four aldehydic groups (COH).

At last the body thus obtained gives protein by the action of hydrogen and H_2S derived from decomposed water and reduced sulphuric acid:

$$6\,C_{12}H_{17}N_3O_4 + 6\,H_2 + H_2S = \overset{\text{The simplest formula of protein.}}{C_{72}H_{112}N_{18}SO_{22}} + H_2O.$$

This hypothesis was strongly criticised by E. Schultz.* Among his objections one deserves special notice, namely, that in scientific explanation such indefinite factors as the "vibrations of living molecules of protein" must be carefully avoided—a factor to which Löw has taken recourse again in his new hypothesis, concerning the formation of sugar.†

It would be useless to go into detailed criticism of this hypoth-

* Ueber die Eiweissumsatz in Pflanzenorganismus—Landwirtschaftliche Jahrbücher, 1885; Just's Berichte, 1888. The hypothesis proposed by this author to supply the place of that of Löw seems to me, indeed, more remote from probability than the criticised one.

† Berichte deutschen chem. Gesellsch., 22: 482.

esis; but concerning the first reaction it may be remarked that while the given construction could be applied to the fungi, which can assimilate ammonia as easily as other nitrogen compounds, it could not apply to green plants, or at least to the phanerogams, since we know that they receive not only their nitrogen in the form of nitrates, but we have also certain data indicating the nature of the first transformation of these nitrates. And this is the only point in the whole process on which experimental researches have thrown some light.

The purely chemical investigation of A. Emmerling* has shown that oxalic acid can decompose very dilute solutions of potassium or calcium nitrate by combining with the base and setting free the nitric acid.† The most interesting consequence of this fact is the behavior of the oxalic acid in the presence of nitrate of potassium and carbonate of calcium. Pure oxalic acid does not dissolve calcium carbonate, because of the formation of thin insoluble layers of calcium oxalate, which preserves it from the action of the acid. But as soon as we add a small quantity of nitrate of potassium it is decomposed, and the nitric acid, set free, dissolves the calcium oxalate, producing calcium nitrate, which is again decomposed by the prevailing mass of oxalic acid. Thus a small quantity of potassium nitrate can by its ferment-like action assist in dissolving a large amount of calcium carbonate.

Thus the observation of Schimper concerning the disappearance of nitrates in the green cells of leaves and the simultaneous accumulation of crystals of calcium oxalate, lead to the conclusion that the first change to which nitrates are exposed in leaves consists in setting free the nitric acid.

The nitric acid ought then to be the starting point of our construction. Such a reaction is presented in the hypothetical equation of A. Mayer, which represents this reaction:

A carbohydrate. Protein without sulphur.

$$C_{37}H_{74}O_{37} + 6HNO_3 = 2C_{12}H_{19}N_3O_4 + 21H_2O + 13CO_2$$

The first member of this equation is a multiple of CH_2O—the simplest formula of carbohydrates; the first number of the right

* Landwirtsch. Versuchsstationen, **34**: 109.

†R. A. Wood has proved the same for pure water (Amer. Chem. Journal, 1895).

side is the simplest formula of protein, with the omission of the sulphur.

The equation shows that nitric acid and a carbohydrate can produce protein without setting free other products than those which are produced by respiration, namely, carbonic acid and water.

This reaction is otherwise represented by Berthelot and André, whose considerations are based upon chemical researches concerning the amount of calcium carbonate, oxalic acid and proteids at different periods of life of a plant and in its different parts.*

Comparing the formula of formic aldehyde with that of oxalic acid, we see that when the latter is produced from the former it would have an excess of hydrogen:

$$2CH_2O + 2H_2O = C_2H_2O_4 + H_6$$

If we take into consideration the equality of volumes of carbonic anhydride and oxygen by the assimilation, the surplus of hydrogen shows that besides the oxalic acid a substance richer in hydrogen (or poorer in oxygen) than carbohydrates is produced. This may be the protein. The amount of protein found in the leaves of *Rumex acetosa* by the quoted authors answered fairly well to that of the oxalic acid, as needed by such a supposition. The oxalic acid is to be considered as one of the products oxydized, being formed as the reverse side of the reduction of proteids.

A. F. W. Schimper,† agreeing with Emmerling, that amides are the predecessors of proteids, considers in accordance with the expressed view of Berthelot and André the oxalic acid as an indirect product of that process and gives the following equation to explain the formation of amides:

$$\underset{\text{Glucose.}}{C_6H_{12}O_6} + 2\underset{\text{Nitric acid.}}{NHO_3} = \underset{\text{Asparagine.}}{C_4H_8N_2O_3} + \underset{\text{Oxalic acid.}}{C_2H_2O_4} + 2H_2O + 3O$$

The three atoms of oxygen are added to the exhaled mass of that element giving a little surplus over the amount of absorbed CO_2, which is generally observed.‡

*Comptes Rendus, **101**: 24, and **102**: 995, 1043.

† Flora, 1890. (Zur Frage der Assimilation der Mineralsaltzen in der Pflanze, 242.)

‡ *L. c.*, 260.

The above quoted equation is in accord with the views advanced by Holzner,* upon the participation of the oxalic acid, who considers it as a product of proteids, destined to decompose the nitrates, phosphates and sulphates of calcium introduced into the plant and to eliminate that element in an insoluble compound, a view which was confirmed experimentally as to the latter part by Emmerling. The quantitative relation of both oxalic and nitric acids is just the same in the above mentioned equation as needed by the supposition. It is two molecules of HNO_3 for one molecule of oxalic acid.

On the contrary Palladin† claims, that the oxalic acid is produced in the second stage of the reaction by the transition from amides into proteids and represents the process thus:

$$\overset{\text{Asparagin.}}{9\ C_4H_8N_2O_3} + \overset{\text{Glucose.}}{9\ C_6H_{12}O_6} = \overset{\text{Protein (without S).}}{C_{72}H_{112}N_{18}O_{22}} + 9\ C_2H_2O_4 + 23\ H_2O + 2H_2$$

This supposition does not contradict that accepted by Schimper's formulae; Berthelot and André found that the amount of oxalic acid in the form of soluble oxalates in fresh leaves is nearly equal to that found with calcium thus agreeing with the last equation in which, as well as in that of Schimper one molecule of oxalic acid is produced for two atoms of nitrogen, the amount of oxalic acid combined with calcium (supposing that the nitric acid is absorbed by the plant only as calcium nitrate) being thus equal to its surplus over that element.

Such are the chief facts and the attempts to give an account of them. Trying to go somewhat further in this line the best way seems to me to start (as did Pfeffer) with a per cent. composition of both asparagin and a proteid, for instance legumin, calculated as to the equal amount of nitrogen, and to compare their difference with the percentage composition of a carbohydrate, as, *e. g.*, glucose. We have then the following table of which the first three columns are taken from Pfeffer's memoir‡ the fourth is obtained by multiplying the percentage composition of the

* Flora, 1867.

† Berichte deutsche bot. Ges. **5**: 326.

‡ Pringsheim's Jahrbücher, **8**: 355 *seq.* 1872.

glucose with 0.91 in order to reduce its amount of carbon to the same number as represented in the third column :

Asparagin.	Legumin.	Difference.	Glucose.
C = 64.9	C = 36.4	+ 28.5	C = 28.5
H = 8.8	H = 6.1	+ 2.7	H = 4.7
N = 21.2	N = 21.2		
O = 30.6	O = 36.4	− 5.8	O 37.8
125.5	100.0		71.0

The difference between the two latter columns is

$$H = 2 = H_2$$
$$O = 43.6 \text{ or nearly } 2\tfrac{2}{3}\ O$$

which give together H_2O and about $1\tfrac{2}{3}$ O in surplus for each two atoms of N. In other words the transition from amides to proteids, supposing that the lacking elements are supplied by the carbohydrates, is a reduction. It may be, that this part of the synthesis requires the action of those strongly reducing bodies, which were found in the leaves by Schimper; for, as we know, the amides can be accumulated in darkness while the formation of proteids from them is connected with the action of light upon chlorophyll as stated by Schimper. The new experiments in this line* show indeed, that if the plants have at their disposition an abundant supply of carbohydrates they can produce this synthesis in darkness : This does not appear strange, for they are then placed in the same conditions which exist generally in fungi, the needed reducing energy being supplied by the oxidation of the surplus of sugar.

Another point to be considered is the origin of the oxalic acid. We have seen that Schimper as well as Berthelot and André consider it as an indirect product of the synthesis of proteids and this opinion generally prevails among physiologists in opposition to the older supposition of Holzner, who considered it as the result of their decomposition. On the other hand we see that oxalic acid is produced at nearly every decomposition or splitting of the proteid molecule.

The only fact which can throw any light about the question

*The above quoted pieces of work of Berthold, Hansteen and Kinoshita; W. Zaleski in Ber. deutsch. bot. Ges. **15** : 536.

as to the true origin of oxalic acid in plants, is the distribution of that compound in different organs of the plant. This point, as regards the oxalic acid bound to the calcium and forming insoluble crystals, was very carefully studied by Schimper * and by Kohl.†

The former distinguishes four types of calcium oxalates, adding a new one to the three proposed by Schimper: (1) The *primaries* are found in buds and are produced independently of assimilation; (2) The *secondaries* originate in the chlorophylic parenchyma and are connected with assimilation; (3) The *tertiaries* are found in the neighborhood of sclerenchymatous cells and also in fruits and seeds, where reserve-substances are accumulated; (4) The *quaternaries* are deposited in leaves in the autumn and remain there.

Beginning now with the fourth category, we know, that in the autumn new proteids are not formed in leaves, but on the contrary, the larger portion of those that constitute the protoplasm of the cells, is dissolved and transferred into the stem; this transfer is most probably accomplished after the splitting of the proteids into amides and carbohydrates. The most abundant production of oxalic acid in plants is then due to the decomposition of proteids. It can be objected that the larger part of oxalic acid could have been produced at any earlier period of development of leaves being then in form of soluble compounds and that the sudden appearance of a large amount of crystals in autumn is due to the supply of calcium. But we have no reason for supposing that large amounts of calcium are brought into the leaves at a time when their vital functions are declining.

In reality the above quoted results of Berthelot and André concerning the distribution of oxalic acid in *Rumex acetosa*, containing a large amount of soluble oxalates seems to contradict our conclusion; but the same authors found in other plants (*Amarantus caudatus*, *Chenopodium quinoa*) quite opposite relations, and they add, after having presented the results of analysis of the first of these plants: "that these latter plants show quite a different mode of generation and physiological functions" (Ceci ac-

* The above quoted article in Bot. Zeitung, 1888.

† Anatomisch-physiologische Untersuchungen über Kalksaltze und Kieselsäure in den Pflanzen, 1889.

cuse un mode de génération et des fonctions physiologiques toute differentes†). It is then not improbable that such plants as *Rumex* and other "oxalic" plants represent some deviation from normal conditions.

The deposition of calcium oxalate in places where thick membranes are formed was noticed long since by Sachs, and it is very natural to associate this phenomena with the production of cellulose. The only known method by which this body can be obtained is through the action of living protoplasm and that suggests the idea, that the cellulose is a product of proteids. A direct transition of other carbohydrates, as sugar or starch, into cellulose was never observed either in the chemical laboratory or in plants; and we can not imagine the rôle of the protoplasm in this process, otherwise than by supposing that these carbohydrates become constituent factors in the proteid molecule, and from the reduction of this molecule the cellulose is derived.

Now the formation of the crystals of oxalates depends upon two factors: the formation of oxalic acid and the supply of calcium in amount sufficient to bind that acid. Both factors are present in the considered case, for where large amounts of cellulose are deposited by the protoplasm of the cells (as by the formation of sclerenchymatous elements), large supplies of carbohydrates are necessary to form anew the protein molecules of the protoplasm, and the transfer of carbohydrates, as both Schimper and Kohl have shown, is strictly connected with the presence of calcium, which is considered as a "vehicle" for these compounds.

In the same way we can explain the formation of oxalic crystals in buds; the predominating phenomenon in this young tissue is the division of cells and the production of a large amount of cellulose membrane, which, according to our supposition, involves a large supply of calcium (as "vehicle" for carbohydrates) and the consequent formation of oxalic acid.

As to the oxalates (called secondary), formed in the chlorophylic tissue of the leaves, the conditions are more complicated. Schimper has proved that their formation "is dependent upon light and chlorophyl, but not upon assimilation."† Their

*Comptes Rendus, 102: 1044.

† Bot. Zeitung, 1888, 69.

amount does not diminish when the plant is put in a position in which it cannot assimilate, as, for instance, is the case when is in an atmosphere deprived of carbonic anhydride. Schimper found that in such conditions proteids cannot be produced by the plant; thus the formation of these crystals cannot depend upon the formation of proteids. But although the formation of proteids is one of the essential functions of the leaf parenchyma, we know that another process is taking place in them, and that is respiration. Whether or not we accept the view that the respiration of plants is essentially based upon the spontaneous dissociation of proteid molecules (the intra-molecular respiration), we cannot overlook the analogy between the function of carbohydrates as respiratory material in animals and plants.

When the assimilation goes on normally, the cellulose deposited by the decomposition of the proteid molecules augments the mass of the plant, while the assimilated carbohydrates are used partially in the reconstruction of that molecule, partially burnt out, the same as in the animal organism a product of proteids—the fat—is stored up, when the animal is abundantly fed with carbohydrates. But, if the production of carbohydrates is not sufficient, the material produced by the proteids is burnt the same as fat is burnt in animal organism under the same conditions. The amount of proteids decomposed by respiration, and consequently that of the oxalates is nearly the same, whether assimilation takes place or not; only in the last case the growth of the plant is hindered, for the part of the protein molecule deprived of nitrogen, will be oxydized into H_2O and CO_2, while its part containing nitrogen will increase the amount of amides, which, as is known, is really observed in such conditions.

The dependence of the secondary oxalates on light and chlorophyl can be explained by the proteid influence of these factors upon the transpiration or, in other words, upon the ascension of water from the soil towards the leaves, and the introduction of salts of calcium in quantities necessary to bind the produced oxalic acid. This dependence of the secondary oxalates upon transpiration was directly proved by Schimper*; the independence of the primary ones from that function, proved by the same investigator, can be

* *Loc. cit.* 89.

explained from the above statement, namely, that the necessary amount of calcium is never lacking in this case, because these organs being unable to produce the carbohydrates indispensable for their growth, these bodies must be transferred to the other parts of the plant, and that transfer is, as we know, fulfilled in form of a combination with calcium.

We can thus consider a large part if not all the oxalic acid produced in plants* as a final product of decomposition of proteids in a certain degree analogous to the carbamide in animals. The analogy is increased by the fact that the oxalic acid is either ejected from plants in the fallen leaves, or reduced to a state of insolubility from which, in most cases, it is never brought forth. It is thus an excretion, comparable to the carbamide in animals. If these inductions are true, we can propose a very general question : *What is the reason for such a difference between terminal products of decomposition of the proteid molecule in animals and in plants* ?

We find a fact of equal generality which enables us to answer this question : that is, the reduction of nitric acid, common to all chlorophylic plants. We do not know exactly the stages through which this reduction goes, but it is not to be doubted that one of them must be nitrous acid (NHO_2). The salts of this acid are found in plants only in very small amounts, but that is easily explained by their quick transformation into other compounds.

The action of nitrous acid or its anhydride upon the compounds of an amidic type is very characteristic. When the reaction is violent the place of the amido group (NH_2) is taken by the hydroxyl group (HO), the nitrogen being set free ; in other circumstances all the nitrogen remains combined with the radical, producing a diazo compound, while the hydrogen of the amido group and a part of the hydrogen of the radical is combined with the oxygen of the nitrous acid.

These two modes of action of the nitrous acid are exemplified by the following equations :

If we take the oxamide (the amide of the oxalic acid) the result will be oxalic acid, nitrogen and water :

* Schimper admits that the whole amount of oxalic acid in plants need not necessarily have the same origin (*loc. cit.* 69).

$$\overset{\text{Oxamide.}}{C_2O_2{<}^{NH_2}_{NH_2}} + 2\,HNO_2 = \overset{\text{Oxalic acid.}}{C_2O_2(OH)_2} + 4N + 4H_2O$$

But, if we act cautiously with hyponitrous acid upon the glycocol (the amido-acetic acid) we obtain at first the ether of that acid and of the glycocol, which afterwards yielding water gives the diazo-acetic acid, as shown by the equation

$$\overset{\text{Ether of glycocol and nitrous acid.}}{C_2H_5.CO_2.CH_2.NH_2.NO_2H} = \overset{\text{Diazo-acetic acid.}}{C_2H_5.CO_2.CH{<}^{N}_{N}} + 2H_2O$$

We have seen that the chemical functions of the proteids compel us to admit the group

$$C_2O_2{<}^{N=}_{N=}$$

as the basis of the molecule of these bodies. It is simply the oxamide group, introduced in one of the above given equations. Each of the two atoms of nitrogen has in that group two free units of affinity. If we denote with R and R_1 two univalent radicals containing C, H, O, N and S, we can represent a molecule of protein as follows:

$$C_2O_2{<}^{N{<}^{R}_{H}}_{N{<}^{R_1}_{H}} \text{ or } {}^{R.HN}_{R'HN}{>}C_2O_2$$

A molecule of such structure can give according, to the reagents which will act upon it, either carbamide or oxalic acid.

By hydrolysis it will be split at the places of junction of the radicals R and R_1 with the atoms of nitrogen, and the result will be as follows:

$$\overset{\text{Protein.}}{{}^{R.HN.}_{R_1HN}{>}} C_2O_2 + 2H_2O = R.OH + R_1OH + \overset{\text{Oxamide.}}{{}^{H_2N}_{H_2N}{>}C_2O_2}$$

the oxamide then gives as known by oxydation carbonic anhydride and carbamide

$$\overset{\text{Oxamide.}}{{}^{H_2N}_{H_2N}{>}C_2O_2} + O = \overset{\text{Carbamide.}}{CO{<}^{NH_2}_{NH_2}} + CO_2$$

The remainders of the first equation $R.OH$ and R_1OH are poorer in nitrogen than protein. It is the type of disaggregation of proteids in animals.

If the nitrous acid will act on such a molecule, it will split at the junction of the nitrogen atoms with the group C_2O_2, as was the case in the above quoted reaction with oxamide and nitrous acid; but if the reaction proceeds very slowly the nitrogen will not be set free. Keeping the analogy with the above given reaction of NHO_2 and the glycocol we can represent the supposed process as follows:

$$\overset{\text{Protein.}}{\left.\begin{matrix} RHN \\ R_1HN \end{matrix}\right\}} > C_2O_2 + 2HNO_2 = \overset{\text{Oxalic acid.}}{C_2O_2(HO)_2} + 2H_2O$$

$$\overset{\text{Diazotic compounds.}}{+ (R - H)''\left\langle \begin{matrix} N \\ \| \\ N \end{matrix} \right. + (R_1 - H)\left\langle \begin{matrix} N \\ \| \\ N \end{matrix} \right.}$$

In other words each of the radicals R and R_1 losing one atom of hydrogen (which is used for the production of water with the oxygen of the nitrous acid) and developing to a new value of affinity, combines with the now formed diazo group $(-N=N-)$.

This ought to represent the transformation of the proteids in plants, which, as we know, *do not lose their nitrogen.*

The known fact that the secondary and the tertiary amides of the aromatic series do not give diazotic compounds with nitrous acid,* cannot be quoted against the possibility of the supposed reaction. For (1) The diazotic compounds of the fat series differ much from those of the aromatic one as well in their constitution as in their properties, and (2) As we know very little about them the argument based upon the ignorance of such a reaction loses its strength. Then, we must remember that the reaction to which the production of diazotic compounds is due, belongs to those in which all is dependent upon the conditions of action of the agents; we are, indeed, encouraged to suppose that the subtleness of the transition in plants surpasses even the most delicate chemical operations in our laboratories that we can imagine.

* From the secondaries nitroso-amides are obtained; the tertiaries give compounds with a nitroso group (NO) on the benzolic nucleus (Confr. Ladenburg, Handwörterbuch der Chemie, 3: 194).

The above presented hypothesis lacks direct proof. My own repeated attempt to produce the reaction of dissociation supposed for plants, either through action of gaseous N_2O_3 or nitrite of potassium (KNO_2), or soda ($NaNO_2$) in presence of any acid (hydrochloric or acetic) upon the albumin did not give any definite result.* This is certainly no objection against the validity of the hypothesis. The conditions for such a reaction are probably very delicate and very complicated and remain to be discovered. But among recent pieces of work there are some which give an indirect support to this hypothesis.

Drexel † obtained through action of hydrochloric acid and stannous chloride on albumin a base (*lysatine*, $C_6H_{13}N_3O_2$) which gives carbamide when treated with baryta water. This reaction shows, as the author deduces, that carbamide is not a product of oxydation, but of hydrolysis. The same result is reached through physiological deductions.‡ A fact of greatest interest for physiologists is that the arginine ($C_6H_{14}N_4O_2$ obtained by Schultze from the seeds of *Lupinus* and differing from lysatine only by the addition of NH, gives also carbamide with baryta water.§ It proves that a wide difference in the constitution of animal and vegetable proteins is not the ground for the different terminal products, but only the difference of the chemical processes in both.

On the other hand Buchner and Curtius, using soda nitrite on the product of the reaction of hydrochloric gas and alcohol on gelatine, obtained a diazotic compound, which differs very strikingly from other compounds of this kind by its stability; thus, *e. g.*, it can be boiled without decomposition. This compound was obtained in a large amount (150 grains from 400 grains of gelatine) and ought to be the only product of the reaction. The investigation of the products from the action of iodide upon these compounds leads the authors to one of the following formulae:

* In the first case it seemed not to be produced by any change in the albumin; in the second xanto protein was the constant product of the reaction.

† Ueber die Bildung des Harnstoff aus Eiweiss in the Berichte deutsch. chem. Gesellsch., 1890: 3096. Confr. also Siegfried, Zur Kenntniss der Spaltungsproducten der Eiweiss *Ibid*, **24**: 418. 1891.

‡ *Cf.* A. Gautier, Chimie de la cellule vivante, 1895, passim.

§ Ber. deutsch. chem. Ges. **24**: 1098. 1891.

Ether of the diazo-oxy-acrylic acid.

$$\begin{array}{l} CN_2 \\ \| \\ C(OH) \\ | \\ CO\text{-}O\text{-}C_2H_5 \end{array}$$

or

Ether of the diazo-lactic acid.

$$\begin{array}{l} CH.N_2 \\ | \\ CH(OH) \\ | \\ CO\text{-}O\text{-}C_2H_5 \end{array}$$

These facts show the possibility of such a reaction, as was suggested both in animals and in plants which explain two very general physiological facts, viz.:

1. That the terminal products of disintegration of the proteid molecule are different in plants and in animals.

2. That green plants cannot use the ammoniacal compounds for the production of proteids, while the mediating links in that process are amides, compounds with hydrogenized nitrogen and not with the oxydized one as is found in nitric acid.

The first is explained by the fact that in the animal organisms there are no conditions for the production of nitrous acid, while in plants it might be produced as one of the stages of deoxidation of the nitric acid. The second, by the necessity of that acid for green plants and thus the impossibility of omitting that stage of deoxidation and of beginning the process with compounds containing only hydrogenized nitrogen. (In fungi, as we know, the process must be different, and it is proved that they can use the amidic ammoniacal compounds as supply of nitrogen.)

The logic of chemistry seems to impose upon us this hypothesis with almost irresistible necessity. All that we know about the chemical process in organisms teaches us that these processes are produced so as to pass through all the consecutive stages and compounds mediating between the initial and the terminal one. If we represent the transition from nitric acid to the amides through all known stages of reduction we obtain the following series of groups:

Nitro.	Nitroso.	Diazotic.	Hydrazines.	Ammonia and amides.
$-NO_2$	$-NO$	$-N=N-$	H_2N-NH_2	NH_3

We see thus that the diazo compounds take the middle place between the oxidized nitrogen of acids and the hydrogenized of hydrazines and amides. It is not improbable that the hydrazines

are the agents of many reductions, such as the reduction of silver, which, as Löw and Bokorny have shown, constitute a property of living plasma, of those proteids in which the process of disaggregation and regeneration of molecules is still going on.

This regeneration is produced by means of compounds with diazotic groups like those formed in the last equation, and it is easy to see that every process of disintegration is accompanied by an enrichment with organic nitrogen, and as every decomposition of proteids is only a stage to their reconstruction in larger amount, the above discussed question upon the origin of oxalic acids appears under quite a new light; in most parts of the plant (excluding the autumnal leaves) both decomposition and reconstruction of proteids are connected processes taking place at the same time.

I have had already occasion to notice the analogy between the production of cellulose in plants and that of fats in animals. It is natural to suppose that both are produced by some groups of atoms set aside during the above discussed reaction. If in the formula of protein we put groups of atoms X and X_1 containing only carbon, hydrogen and oxygen, instead of NH, it assumes the following structure:

$$C_2O_2 < \begin{matrix} N < \begin{matrix} R \\ X \end{matrix} \\ N < \begin{matrix} R_1 \\ X_1 \end{matrix} \end{matrix}$$

These groups of atoms, being set free in each of the two supposed reactions, would originate the fatty acids in the case of animals, the cellulose or starch in the case of plants. Thus we can represent the continuous process of formation and destruction of proteids in plants as follows:

PROTEIDS (stored in the seeds). + NHO_2 (produced by the reduction of NHO_3 from soil).

→ The compound richer in nitrogen (*diazotic?*) → reduced to amides and combined with the assimilated carbohydrates gives anew

↓

PROTEIDS, which with the HNO_2 produced from the reduction of NHO_3 is further decomposed.

↘ the *cellulose* and the *carbohydrates* consumed by respiration.

↓

Oxalic acid.

It is necessary to notice that this diagram does not require a constant relation between the amount of protein and that of carbohydrates in plants, a relation which really does not exist. The quantitative relation between compounds containing nitrogen and those without it in plants is within certain limits dependent upon the relation of assimilation to the amount of nitric acid absorbed from the soil. The greater the amount of assimilated carbohydrates, the less the carbohydrates, which are derived from proteids, will be burnt. On the contrary, when the amount of assimilated carbohydrates is not sufficient the relative amount of nitrogen in the plant will rise, and since in such conditions proteids cannot be regenerated—that surplus will consist of amides and other nitric compounds of a non-proteid character. Something like this we find in the above quoted results of the analysis of plants grown from seeds in darkness. (*Ante*, p. 39.)

But the amount of cellulose (and other soluble carbohydrates) cannot exceed a certain maximum in respect to nitrogen, and that maximum corresponds to such a state in which the assimilated carbohydrates make up all the loss for respiration, a state probably reached in plants when the conditions of feeding are normal.

Some chemical and physiological facts indicate that in the proteid molecule there are groups of atoms closely connected together and containing each 6 atoms of carbon. That number is basal for the carbohydrates found in organisms and fatty acids, the most common in animals, containing a multiple of that number (the stearic $C_{18}H_{36}O_2$; the oleic $C_{18}H_{34}O_2$). The amides, which are produced in organisms, or through the action of chemical agents upon the proteids contain generally less than 6 atoms of carbon and the most typical of them, leucine is the amido-capronic acid — $C_6H_{13}NO_2$. Only the less defined compounds obtained by Schützenberger (and called by him leucines) seem to make an exception to this rule, but we do not know whether these are chemical individuals or mixtures. All these and many other physiological facts oblige us to admit a near connection between proteids, fats and carbohydrates, and although the transitions from one group to another cannot yet be accomplished in the laboratory, there is no doubt that it is accomplished continually in the organisms themselves.

NEW YORK.

Note on Asplenium Glenniei Baker in Synopsis Filicum, 2d Ed. p. 488

By C. W. Hope

In August, 1898, I had the pleasure of making the acquaintance of Professor Underwood, while he was examining certain genera of ferns in the herbarium of the Royal Gardens at Kew, and I then drew his attention to what I considered a remarkable instance of a locally plentiful Himalayan fern being sparingly found in a few localities in Mexico and in Arizona, U. S. A., having been described from the American specimens as a new species, and I asked leave to send my views as to this fern for publication in the Bulletin of the Torrey Botanical Club.

In the first edition of the *Synopsis Filicum*, under *Asplenium fontanum* Bernh., *A. exiguum* Bedd., from the Nilgiris, is mentioned as being a less divided form, with narrow fronds and ebeneous rhachis, and the authors go on to say that a similar plant had been gathered in Mexico by Mr. Glennie. But in the second edition Mr. Baker set up a new species—"*A. Glenniei* Baker, Hab. Mexico, *Consul Glennie*, Bourgeau, 252.—Very like some of the forms of *fontanum*." When at Kew, in 1888, I pointed out to Mr. Baker and Colonel Beddome that the specimens of *A. Glenniei* in the Royal Herbarium were merely a common north-west Indian fern, which I had been calling *A. exiguum* Bedd.—Mr. Baker objected that there was a wide interval between Mexico and the western Himalaya, and Colonel Beddome remarked that neither the Himalayan nor the Mexican plant could be his because the fronds were not prolonged at the apex. Prolongation of the rhachis into a "naked tail often bearing a young plant" was a character given by Beddome in his original description of the species, in the "Ferns of S. India," published in 1873, though this entry was omitted from his Handbook of 1883, where he degraded the plant to the rank of variety. This proliferous form of the tip I found, on returning to India, to be a normal, though perhaps not an invariable character of the Himalayan plant, as it is to be also of *A. micropteron* Baker, Syn. Fil. 488,—"rhachis much

produced beyond lamina, rooting at the tip, Hab. San Luis, 7000, Pearce." But *A. micropteron* differs materially in having a flattened and broadly and interruptedly winged rhachis, and also in the cutting of the pinnae, and must be considered quite distinct. Mr. Baker's type specimen of *A. Glenniei* (*vide* Ic. Fil. *pl. 1648*) has not a prolonged and proliferous rachis; but in the British Museum there is one plant among *A. fontanum*, ticketed—" U. S. Pacific Coast Flora (new to U. S.) var.—' Conservatory,' Huachuca Mts., Arizona, August 8, 1882, Lemmon Herbarium, Oakland, California," which is exactly the northwest Himalayan fern, and it is proliferous on the pinnae throughout, and also at the apex of the frond. And there are in the same herbarium two specimens from America, named *A. Glenniei* Baker, which are exactly the Himalayan plant. Also, there are in the Calcutta Herbarium three specimens named *A. Glenniei*, from America, one or two of which is the Himalayan fern, the third is not.

The Mexican plant had been named *Athyrium gracile* by Fournier, in his Fil. Mex. 102, published in 1872, and Mr. Baker gave this as a synonym of his *Asplenium Glenniei*, being obliged to reject *gracile* as the specific name because there was already *Asplenium gracile* Fée, and also another plant so named by Pappé and Rawson. Fournier's plant is in the " Herbier de la Commission scientifique du Mexico, recueilli par M. Bourgeau 1865–66." Lemmon's plant, collected in Arizona, 1882, was identified by Baker as *A. Glenniei*, and was cited as *A. Glenniei* Baker, by Eaton in the BULLETIN OF THE TORREY BOTANICAL CLUB, 1883, p. 29, and some specimens collected by Pringle, and by Lloyd, in Mexico in 1886 and 1894, were also so named.

I find no difficulty in separating the Himalayan and North American plant from *A. fontanum* Bernh.; but it is not without hesitation that I came to the conclusion that it is the same as Beddome's Nilgiri plant. Beddome found his plant in only one station, and he then thought it nearly allied to *A. comptorhachis* Kze., which Baker unites with *A. lunulatum* Sw. Mr. Gamble has a dozen plants ticketed *A. exiguum*, which he got near Barliár, on the Nilgiris, 2500 ft. alt., all small and narrow, and with prolonged rhachises. I have seen no S. Indian specimen nearly so large as the Himalayan plant reaches. Of the latter-named plant I wrote the following description about eight years ago:

Plants isolated, or united in tufts by the matted roots; *caudex* erect, short; *stipes* ½–2½ in. l., rarely more than 1½ in., densely tufted, soft, castaneous, clothed at base with linear hair-pointed dark-colored scales, more or less so clothed upwards, scales gradually changing upwards to soft hairs, *frond* linear-lanceolate, bipinnatifid, never nearly bipinnate, 2–9 in. l., ½–1¼ in. br., *rhachis* flattened, winged, green in upper two thirds, the castaneous color of stipes extending farthest up the inferior side, and sometimes in patches; *pinnae* 20–25-jugate, oblong with an expanded base or cuneate, sometimes leafy and then obliquely triangular and less cut, subpetiolate, blunt, costae inconspicuous, undulate laterally, lower pinnae more distinct, shorter but scarcely narrower at base, sometimes trifoliate in shape; segments 3–6-jugate, having 1–6 teeth according to number of veinlets, lower margins concavely cut or scooped out, lowest anterior much cut away; color dark green; *veins* one to each segment sometimes forking near tips; *sori* costular, one at the base of each segment, two or more in lowest anterior; *frond* often very attenuate upwards and then rooting at tip; segments sometimes all truncate or marginate at apex and there proliferous."

The Himalayan habitats I have noted are: The PUNJAB: in *Kuller* 7–9000 ft. alt., one station; in the *Simla Region* 6–9000 ft., not common, but gathered by seven persons separately. In the NORTHWESTERN PROVINCES: in the *Dehra Doon Dist.*, in Iannsar 7000 ft., in the Hill Sanitarium of Mussooree 55–7000 ft., locally plentiful; in *Garhival* 6–7000 ft., not often seen; in the *Kumaun Dist.* 5–10000 ft., in various places.

As to distribution—besides the Mexican and U. S. A. habitats already mentioned—I have noted Waugtu in the Sikkim Himalaya, *Hook. fil. & Thoms.* 1847; the S. Indian stations for Beddome's plant already mentioned: China—Monpine, *David*, 1889; Mengtez; Yunnan, *W. Hancock*, 1893; "shady rocks, very local."

If the Nilgiri (S. India) plant (Bedd. F. S. 1, *t. 146*) be admitted to be the same as the American and Himalayan plants (Beddome added "Himalayas" as a habitat in his Handbook), then Beddome's name *A. exiguum*, being the older, must have priority over Baker's name, *A. Glenniei*. *A. Zunnanense* Franchet in Bull. Bot. Soc. France, 1885, p. 28, which Mr. Baker, in Ann. Bot., 1892, placed as a variety of *A. fontanum* Bernh., near var. *exiguum*, and of which Beddome in his Suppt. of 1892, after describing it, says: "Seems hardly to differ from typical *fontanum*," must, I think, also come under *A. exiguum*.

I have not gathered *A. fontanum* Bernh., but I possess numerous specimens, collected by five contributors in the northwestern Himalaya, from Hazára eastward to Kumaun, and have seen many more collected by them and many others from Afghanistan to west Nepal, and, except as to size, I can say that the specimens are very uniform. Mature plants vary from 2½ to 12 inches in height (including rootstock) according to attitude and exposure. The largest I have seen were from Kashmire at an altitude of 4500 ft.; one I have is 12 inches high; and I have a note of another plant which had 16 fresh fronds covering, as dried, an area of 15 × 10 inches. There is never any resemblance to, or passage into *A. exiguum* Bedd. The Indian specimens agree with the description of *A. fontanum* in that they are all distinctly *bipinnate; A. exiguum* (or *Glenniei*) is never more than *bipinnatifid*. *A. fontanum* is always of a pale grass-green color—almost yellowish sometimes: *A. exiguum* is always dark green. And, corresponding to the cutting and venation, the position of the sori in the two plants is quite different. In *A. fontanum* the sori are all placed in the pinnules and segments, on the veinlets, without any relation to the costa of the pinna: in *A. exiguum* they are in a row on each side of and close to the costa, curving outwards with the veins towards the segments. *A. fontanum*, so far as I know, never has fronds with the rhachis prolonged and rooting at the point; nor have I seen it proliferous at the pinnae. Both these features are characteristic of *A. exiguum*.

A great deal of the European material called *A. Halleri* Willd. (under *Aspidium*), which by some botanists is reduced to *A. fontanum*, is more like *A. exiguum* than like *A. fontanum*, but the fronds of *A. Halleri* are broader for their length, and the sori do not lie along the costa or secondary rhachis. Willdenow said of *A. Halleri*: "Ab *A. fontano* ab unde distincta species." *A. exiguum* varies considerably in width of frond and pinnae and in cutting, but the variations are all away from the direction of *A. fontanum*. Indeed I should find it difficult to point out identical characters, or even resemblances, between the two plants.

A. exiguum is abundant in many places within the municipal limits of Mussooree, the Hill Sanitarium in the District of Dehra Doon, Northwest Provinces, India—where I have chiefly observed

it—at altitudes of about 5500 to almost 7000 feet, on (usually) limestone, moss-covered rocks in the forest, generally with a northern aspect. It spreads itself out like aster, the prolonged fronds bending backward until they hang their tips in the moss, seeking for cracks or crevices, or earth, in which to root. The fronds last for two years at least, living through the winter in frost and snow, and through the succeeding dry, hot season, in a shriveled and apparently dead state until the rainy season comes in June or July, when they uncurl, and then frequently, if they have not already done so, produce young plants on their tips, or on their pinnae. This is followed by the springing up of fresh fronds from the same roots, which are not generally proliferous in that season, so far as I have seen. Judging from the numerous herbarium specimens I have seen *A. fontanum* of the Himalaya has a more erect habit than *A. exiguum*, and is never proliferous.

The late Mr. H. F. Blanford, F.R.S. (*vide* his "List of the Ferns of Simla, in the N. W. Himalaya between Levels of 4500 and 10,000 feet," Jour. Asiat. Soc. Bengal, **57**: 294–315. 1888), said that *A. exiguum* was rare in the neighborhood of Simla. In Mr. J. S. Gamble's collection I have found three sheets—with eleven specimens—from Simla. On the five days' march from Simla to Bági, eastward on the Great Thibet road in 1886, I saw only two or three specimens at about 8000 feet altitude, but the fern may be more abundant off the road at lower levels. In 1861 I saw one plant of *A. exiguum* at Naini Tál, in Kumaun, N. W. Himalayas, by the side of the lake, but none anywhere else or on the way to Almora, thirty miles northward; and there is not much record of it from the eastward of Mussooree. There is no passage from *A. exiguum* to the next species, *A. varians* Hk. and Gr.

KEW, Nov. 1898.

New Species of Fungi

By Chas. H. Peck

Lepiota coerulescens

Pileus thin, convex, obtuse or slightly umbonate, squamulose, whitish, the squamules and the center brownish, flesh and surface of the pileus becoming blue in drying; lamellae thin, close, free, white, becoming blue in drying; stem slender, equal, brownish, annulate, the annulus membranous, persistent, externally tinged with blue when dry; spores elliptic, 7 μ long, 5 μ broad.

Pileus 1.5–2 cm. broad; stem 3–5 cm. long, 2 mm. thick.

Ohio. C. G. Lloyd.

The species is closely allied to *Lepiota cristata*, from which it is easily separated by its assuming blue tints in drying.

Lepiota gracilis

Pileus thin, convex or campanulate, somewhat umbonate, white, the center and the scales formed from the ruptured cuticle blackish brown; lamellae close, ventricose, free, whitish; stem long, slender, floccose or fibrillose, blackish brown, the annulus membranous, persistent, conspicuous, blackish brown on the lower surface; spores broadly elliptic, 6–7 μ long, 4 μ broad.

Pileus 6–10 mm. broad; stem about 2.5 cm. long, scarcely more than 1 mm. thick.

Black humus in woods, Elmsdale, Canada. September. J. Dearness.

A small, graceful species which when young is probably wholly covered by the blackish brown cuticle, but by the expansion of the pileus this soon ruptures, except in the center or on the umbo, revealing the white surface beneath and forming spot-like scales.

Tricholoma piperatum

Pileus rather thin, firm, dry, convex, obtuse or subumbonate, virgate with innate brownish fibrils, varying in color from grayish brown to blackish brown, sometimes with greenish or yellowish tints, flesh white or whitish, taste acrid; lamellae broad, close, rounded behind, adnexed, whitish or yellowish; stem generally short, equal, solid, silky, slightly mealy or pruinose at the top, white or slightly tinted with yellow; spores elliptic, 6–7 μ long, 5 μ broad.

Pileus 4–7 cm. broad; stem 5–7 cm. long, 6–12 mm. thick.

Woods, Massachusetts, G. E. Francis; Pennsylvania, Charles McIlvaine.

The central part of the pileus is sometimes a little darker than the rest. The peppery or acrid taste is very distinct and remains in the mouth many minutes. This and the innately fibrillose character of the pileus are distinguishing characters of the species. The plants appear from September to November.

Hygrophorus Morrisii

Pileus thin, convex, obtuse or umbonate, covered by a viscid separable pellicle, even, grayish brown or blackish brown, flesh whitish; lamellae subdistant, adnate or slightly decurrent, often slightly eroded or uneven on the edge, white; stem rather slender, equal or slightly tapering downward, solid, straight or flexuous, flocculently furfuraceous, pallid or brownish; spores elliptic or oblong, 10–12 μ long, 5 broad.

Pileus 1.5–2.5 cm. broad: stem 4–6 cm. long, 3–5 mm. thick.

Under pine trees, Waltham, Mass. November. G. E. Morris.

This species is closely related to *H. pustulatus* Fr., but differs from it in the entire absence of pustules or papillae from the uniformly colored pileus and in having a solid stem which, though somewhat scurfy, is not rough or scabrous with black points. The presence of concolorous papillae on the pileus and of black points on the stem of *H. pustulatus* is given by Fries special emphasis in his description of this species. In Icones he describes the lamellae as very entire (integerrimae) which character is not applicable to our plant. These differences seem to me too important to be disregarded and I take pleasure in dedicating this interesting American species to Mr. George E. Morris, who sent me numerous specimens of it in fine condition.

Volvaria umbonata

Pileus thin, campanulate, becoming convex or nearly plane, prominently umbonate, distinctly striate, slightly viscid when moist, silky when dry, white; lamellae moderately close, free, not extending beyond the margin of the pileus, pale flesh color; stem equal or slightly thickened at the base, glabrous, solid, white, the ruptured membranous white volva persistent, irregularly split or lobed on the margin and forming a shallow cup

at the base of the stem; spores broadly elliptic, uninucleate, variable in size, 5–7 μ long, 4–5 μ broad.

Pileus 2–3 cm. broad; stem 5–6 cm. long, about 4 mm. thick.

Lawns and grassy places, Ohio, Lloyd.

The species is most closely allied to *Volvaria media* (Schum.) Fr., from which it is distinguished by its larger spores and the striate margin of the pileus. In our plant the striations sometimes extend to the umbo. *Volvaria emendatior* (B. & C.) is described as having a white umbonate pileus with striate margin, but it is a much larger plant with the lamellae extending beyond the margin of the pileus and with cymbiform spores 12 μ long.

Clitopilus irregularis

Pileus thin, irregular, sometimes eccentric, nearly plane, glabrous, reddish brown, flesh white; lamellae rather broad, subdistant, decurrent, whitish becoming tinged with flesh color; stem short, solid or spongy within, externally fibrous, colored like the pileus, usually caespitose; spores pale flesh color, elliptic, 6–7 μ long, 3–4 μ broad.

Pileus about 2.5 cm. broad; stem about 2.5 cm. long, 2–4 mm. thick.

Manured ground, London, Canada. October. Dearness.

Leptonia aeruginosa

Pileus thin, convex, umbilicate or centrally depressed, striate, aeruginous; lamellae broad, subdistant, adnate, aeruginous, tinged with flesh color when mature; stem slender, glabrous, hollow, colored like the pileus; spores angular, 7.5–10 μ long, generally containing a single large nucleus.

Pileus 1.5–2.5 cm. broad; stem about 2.5 cm. long, 2 mm. thick.

Shaded places in woods, Oxbow river, Canada. August. Dearness.

This small mushroom is quite conspicuous by reason of its peculiar and unusual verdigris color. This fades with age to an ashy green hue.

Flammula aliena

Pileus thin, flexible, broadly convex, umbilicate, dry, glabrous, slightly striate on the margin when old, grayish or pale grayish-brown, flesh white, fibrous; lamellae thin, subdistant, arcuate, de-

current, ochraceous brown; stem firm, fibrous-striate, solid, slightly tapering upward, colored like the pileus, covered at the base with a dense white tomentum; spores ferruginous-brown, globose, 5 μ broad.

Pileus 3–5 cm. broad; stem 5 cm. long, 4–6 mm. thick.

Gregarious on partly buried anthracite coal, Mt. Gretna, Pa. September. C. McIlvaine.

The species is peculiar in its color and habitat. In the dried specimen the lamellae have assumed a brown color with no ochraceous tint. Mr. McIlvaine remarks that it is an edible species, dries well and is excellent when cooked. Its relationship is with *F. anomala* Pk., but it is a larger plant with darker color and a different habitat.

Galera capillaripes

Pileus subcampanulate, obtuse, a little broader than high, even, glabrous, hygrophanous, faintly striatulate and pale ferruginous when moist, paler or buff color when dry; lamellae rather broad, distant, adnate, pale ferruginous; stem very slender, flexuous, glabrous, colored like the pileus; spores elliptic, 8–12 μ long, 6–7 μ broad.

Pileus 4–6 mm. broad; stem 2–3 cm. long, less than 1 mm. thick.

Lawns and grassy places, Ohio. May and June. Lloyd.

This might easily be taken for a dwarf form of *Galera tenera* (Schaeff.) Fr., from which its capillary flexuous stem and more distant lamellae serve to distinguish it.

Crepidotus latifolius

Pileus very thin, submembranous, sessile, suborbicular, 3–6 mm. broad, hygrophanous, striatulate when moist, white and slightly pubescent when dry, flesh white; lamellae very broad, suborbicular, 5 or 6 times as wide as the thickness of the flesh, subdistant, extending beyond the margin of the pileus, white becoming pale ferruginous with age; spores globose, 5–6 μ broad.

Gregarious on much decayed wood, Ohio, Lloyd.

Agaricus maritimus

Pileus very fleshy, firm, at first subglobose, then broadly convex or nearly plane, glabrous, sometimes slightly squamose with appressed spot-like scales, white becoming dingy or grayish brown when old, flesh whitish, quickly reddening when cut, taste agree-

able, odor distinct, suggestive of the odors of the seashore; lamellae narrow, close, free, pinkish becoming purplish brown with age, the edge white; stem short, stout, firm, solid, equal, sometimes bulbous, white, the annulus delicate, slight and easily obliterated; spores broadly elliptic, purplish brown, 7–8 μ long, 5–6 μ broad.

Pileus 5–20 cm. broad; stem 2.5–5 cm. long, 1.5–2.5 cm. thick.

Sandy soil near salt water, Lynn, Nahant and Marblehead, Mass. June to December. R. F. Dearborn.

This is a very interesting and an excellent mushroom. Dr. Dearborn writes that he has used it on the table for fourteen years and that it is the only mushroom that he has ever eaten in which the stem is as good as the cap. He considers it the most hearty and satisfying of all the numerous species that he has ever eaten. Both its taste and odor is suggestive of the sea. The latter is quite strong, and perceptible by one riding along the road by whose side the mushrooms are growing. They sometimes grow in semicircles and attain a larger size in warm weather than in the colder weather of autumn. They are most abundant in August. The flesh when cut or broken quickly assumes a pink or reddish hue on the freshly exposed surface. This is a very distinctive character and with the maritime habitat makes the species easy to recognize. Another species, *Agaricus haemorrhoidarius* Kalchb. exhibits a similar change of color in its wounded flesh, but it is of very rare occurrence with us, does not, so far as ascertained, grow near the sea, has a darker cap and a longer hollow stem. The stem in the maritime mushroom is short and solid. Its collar is very slight and easily destroyed.

Agaricus magnificus

Pileus fleshy, thick, convex, becoming nearly plane or centrally depressed, glabrous, often wavy and split on the margin white or whitish, often brownish in the center, flesh 1.5–2 cm. thick in the center, thin on the margin, white, unchangeable; lamellae numerous, rather broad, close, free, ventricose, white becoming dark purplish brown with age, never pink; stem firm, stuffed with cottony pith, bulbous or thickened at the base, fibrillose, striate, minutely furfuraceous toward the base, annulate, pallid or whitish, the annulus thin, persistent, white; spores small, elliptic, 5–6 μ long, 3–4 μ broad.

Pileus 5–15 cm. broad; stem 10–15 cm. long, about 2.5 cm. thick.

Gregarious or cespitose; thin woods, Mt. Gretna, Pa. August. McIlvaine.

A large fine species distinguished from its near allies by the absence of pink hues from the gills. Mr. McIlvaine remarks that it has an anise-like flavor and odor and that when young the whole fungus is tender and high-flavored but when full grown only the caps are edible.

Agaricus argenteus Braendle *in litt.*

Pileus thin, convex becoming nearly plane, slightly silky or glabrous, pale grayish white or grayish brown, shining with a silvery luster when dry, the margin sometimes striate, at first incurved, often revolute when old, flesh whitish, becoming blackish where cut; lamellae close, free, at first brownish, becoming blackish brown or black with age; stem short, glabrous, solid, often narrowed toward the base, the annulus slight, evanescent; spores broadly elliptic, 7–10 μ long, 6 μ broad.

Pileus 2.5–5 cm. broad; stem 2.5–4 cm. long, 4–8 mm. thick.

Lawns and grassy places in rich soil. Often associated with *Stropharia bilamellata* Pk. After rains from April to November. Washington, D. C., F. J. Braendle.

This is a small mushroom, peculiar in having the young lamellae of a dark color and in the absence of any pink hues. The lamellae sometimes become moist and manifest a tendency to deliquesce. The drying specimens emit a strong but not unpleasant odor. Mr. Braendle says that their edible quality is excellent and that it is not impaired by drying.

Psathyra microsperma

Pileus ovate or subhemispherical, becoming deeply convex or subcampanulate, obtuse, even, hygrophanous, brown when moist, paler when dry, slightly floccose when young, flesh brownish; lamellae thin, close, adnate, brown; stem equal, hollow, fibrillose; spores brown, elliptic, 5–6 μ long, 3–4 μ broad.

Pileus 1–2.5 cm. broad; stem 2.5–3 cm. long, 2–3 mm. thick.

Cespitose about old stumps, Ohio. April. Lloyd.

The white floccose tufts of the pileus and the white fibrils of the stem are easily destroyed in handling the specimens. The species is similar in the ornamentation of the pileus to *Psilocybe senex* Pk.

Coprinus laceratus

Pileus thin, at first ovate and covered with a white separable floccose coat which soon separates into scales or patches and

finally disappears, then campanulate, striate nearly to the center, much torn or lacerated on the margin, pale buff becoming darker with age; lamellae thin, close, free, white when young, becoming black; stem equal or slightly thickened at the base, striate, hollow, white; spores elliptic, 12–15 μ long, 8–10 μ broad.

Pileus 2.5–4 cm. broad; stem 5–7.5 cm. long, about 4 mm. thick.

Cespitose on manure mixed with shavings, Ohio, Lloyd.

The glabrate mature specimens resemble very pale forms of *C. micaceus* Fr. Young plants resemble *C. quadrifidum* Pk., but the mature plants do not split to the center as in that species, and the spores are larger than in it.

Polyporus admirabilis

Pilei tufted, large, more or less imbricated, nearly entire centrally depressed or subinfundibuliform, glabrous, white or slightly tinted with pale yellow or cream color; pores minute, rotund, whitish, with thin dissepiments; spores flattened, orbicular, 5–6 μ broad.

Pilei 10–15 cm. broad, united at the base and forming tufts 30 cm. or more in diameter.

Wood of apple trees, Riverside, Maine. August and September. H. P. Burt.

This is a very beautiful and attractive species which is referable to the tribe Merisma. Mr. Burt remarks that the fresh tufts of clear white trumpet shaped pilei are suggestive of a cluster of giant calla lilies.

Craterellus corrugis

Pileus soft, fleshy, flexible, at first clavate, obtuse, flesh colotinted with violet, soon obconic or turbinate, broadly convex or truncate, glabrous, somewhat irregular with an obtuse margin corr rugated by the extension of the hymenial wrinkles, ochraceous buff or pale ochraceous when fresh and moist, somewhat rufescent when dry, sometimes leprously whitened in the center, flesh white, very soft, soon shrinking and leaving the pileus hollow, the hymenium colored like the pileus, conspicuously corrugated or wrinkled when fresh or moist, the wrinkles less conspicuous when dry; stem short, equal or tapering downward, colored like or a little paler than the pileus; spores white, 8–10 μ long; 4–5 μ broad.

Pileus 2.5–5 cm. broad; stem 1.5–2.5 cm. long, 6–8 mm. thick.

Thin oak woods, Massachusetts. September to November. G. F. Francis.

This species is closely related to *C. clavatus* (Pers.) Fr. from which it differs in its coloration, larger size and smaller spores. Sometimes the plants are united at the base, forming small clusters. The species is also liable to be confused with *Craterellus pistillaris* Fr. and *Clavaria pistillaris* L., unless the distinguishing characters are carefully observed.

Fistulina firma

Pileus fleshy, firm, flexible, dimidiate or reniform, convex, covered with a minute somewhat tufted tomentum, buff verging toward isabelline, flesh very white; tubes short, 1–2 mm. long, whitish, abruptly terminating at the stem; stem firm, solid, somewhat irregular, cinnamon brown above, paler below, white within; spores minute, subglobose, about 3 μ broad.

Pileus 6–7 cm. broad; stem 2.5 cm. long, 8–12 mm. thick.

Among fallen leaves, near Manchester, N. H. October. Mrs. A. M. Hadley.

This is evidently a very rare and very distinct species. Only two specimens were found and these were united at the base. They were apparently growing from the ground where it was covered with fallen leaves, but probably the base of the stem was connected with some root or piece of buried wood. Most of the described species have more or less red in the color of the pileus, but in this there are no red tints. The tomentum is of such a character as to give the pileus a pulverulent appearance, but it is not at all dusty nor easily separable. The flesh is pure white, of a uniform but firm texture and a slightly acrid flavor. The tubes are very minute and very short. The mass is rounded next the stem, ending abruptly and not at all decurrent.

Helvella nigra

Pileus irregular, cupular, 1.5–2 cm. broad, externally velvety with short few-celled blackish brown or black septate hairs, hymenium even, black; stem 1.5–2 cm. long, solid, deeply sulcate and lacunosely pitted, velvety, black; asci 8-spored, 150–200 μ long, 12–15 μ broad; spores elliptic, 15–20 μ long, 10–12 μ broad, usually containing a single large shining nucleus.

Ashes of an old camp fire, Mt. Katadin, Maine. September. F. L. Harvey.

This species is externally black and everywhere clothed with short thick black hairs except on the hymenium, but the inner sub-

stance is white. It is peculiar in having a cup-shaped though wavy and irregular ascomate or pileus. It is possible that this may become reflexed or deflexed with age, but I have seen no such specimens. The stem is rather long and conspicuously sulcate and lacunose, and on this account I have referred the species to the genus *Helvella* rather than to *Acetabularia*. The hymenium is sometimes suffused with a white pruinosity.

Microglossum obscurum

Clubs 8–12 mm. long, about 2 mm. broad, compressed, obtuse, glabrous, tapering below into a stem which is about as long as the club, olive brown or blackish brown; asci clavate, 100–112 μ long; spores fusiform, slightly curved, hyaline, 12–15 μ long, 4–5 μ broad.

Gregarious or cespitose in thickets, Canada. August. Dearness.

The whole fungus is scarcely more than 2 or 2.5 cm. long. It is smaller and more regular than *M. contortum* Pk., and its spores are more narrow. From the very variable *M. multiforme* (Henn.) Sacc. it is easily separated by its darker color.

Mycological Notes.—V

By Byron D. Halsted

The notes for the present issue have this in common that they are all derived from the results obtained at the Experiment Area of the New Jersey Experiment Station. This test field, sometimes called the "Plant Hospital," consists of two acres laid off into six series, each with four plots and the latter are all divided into six equal parts 11 by 33 feet and called belts. These belts are usually the unit of area for any variation in the method of treatment for the crop in the plot.

Nearly all the vegetable and vegetable-fruit crops are grown, some one or more fungi infesting each being under consideration. In some instances the treatment is entirely with the soil, as for club-root of turnip, or scab of the round potato, but in the majority of cases it is by means of various fungicides applied to the aerial portions of the plant, as in the spraying of beets for leaf blight (*Cercospora beticola* Sacc.) or beans for the pod spot (*Colletotrichum lagenarum* Pass.).

The present season closed the fifth year in the existence of these experiment grounds and during all that time some crops have been grown continuously upon the same land. The work with the turnip club-root (*Plasmodiophora Brassicae* Wor.) is a good instance of this latter fact and may well serve as the first note to be recorded.

Lime for the Club-root of Turnips.—Experiments with lime as a remedy for the club-root, due to the subterranean *Myxomycete*, above named, have been carried out upon one plot, one-twentieth of an acre, and divided into six equal belts. Lime, air slaked, was used upon three of the belts, namely numbers 1, 3 and 5, and at the rate of 150, 75 and 37½ bushels per acre respectively, applied April 24, 1894, to the surface of the ground already prepared for sowing, and thoroughly raked in. Belt number 6 received corrosive sublimate and its consideration will be omitted at this time.

The following table gives the yield of turnips in terms of pounds, and sound and clubbed roots for each of the past five years, no additional lime having been applied during that time.

Year	Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6	
	Sound	Clubbed	Sound	Clubbed	Sound	Clubbed	Sound	Clubbed	Sound	Clubbed	Sound	Clubbed
1894	99	2	95	37	75	11	101	14	120	3	127	11
1895	53	1	42	81	135	7	91	36	132	5	79	54
1896	91	0	1	90	87	1	25	65	77	1	22	56
1897	115	0	34	81	117	1			124	4	151	44
1898	86	0	14	77	77	2	64	34	68	1	67	28
Total	444	3	186	366	491	22	281	149	521	14	503	156

It is seen that the amount of diseased roots was much less upon the limed than the unlimed belts. It will be fair to take the first four plots thus dealing with equal areas with lime and without, and under these conditions it is seen that the two limed belts in 1894 gave 13 pounds of clubbed roots to 51 pounds when no treatment was made. The next year shows a greater difference in favor of the limed belts, for in 1895 the yield of diseased roots stood for the treated 8 pounds to 117 pounds for the untreated belts.

In 1896 there was one pound to 155 in favor of the limed belts, and in 1897 the results were practically the same, here, however, one of the check belts was employed for testing the susceptibility of other cruciferae to the *Plasmodiophora*. In 1898 there were two pounds of clubbed roots upon the limed belts to 111 where there was no treatment.

It is seen from the table that the larger amount of lime (belt 1) produced only 3 pounds of clubbed turnips and the half amount of lime (belt 3) yielded 22 pounds, which exceeded the belt with a quarter amount of the lime, namely, 37½ bushels per acre. From this test for five years it seems that 35 bushels of lime per acre is ample to keep the club-root from the land even when the susceptible crop is grown continuously, and two crops each season for at least five years without diminished strength.

By combining the two treated and two check belts the following table is constructed:

	Limited Belts.		Untreated Belts.	
Year.	Sound.	Clubbed.	Sound.	Clubbed.
1894	174	13	196	51
1895	188	8	133	117
1896	178	1	26	155
1897	232	1	68	(162) estimated.
1898	163	2	78	111
Totals.	935	25	501	596

It is seen from this that in a field when the diseased roots outweigh the sound ones, the presence of lime in the soil has the wholesome effect of reducing the disease to near four per cent. of its abundance upon untreated land.

It should be said in addition that under the method of inspection any root that showed the slightest indication of the club-root fungus was excluded from the group of sound specimens and, therefore, this was a discrimination against the treatment, for the diseased roots grown in the limed land were usually only infested to a small extent, while those upon the untreated soil were, as a rule, badly diseased and frequently offensive and of course unmarketable.

Artificial Introduction of Onion Smut.—Smut-infested soil was obtained from a field of a large onion grower in the southern part of the State where *Urocystis cepulae* Fr., had been so fatal that the growing of onions was abandoned. The dry soil thus obtained was added to the open row before the onion seed had been sown and an equal amount upon the covered row, making in all one bushel of the soil to the belt or at the rate of 120 bushels per acre. The seed was sown upon April 23d, and owing to unfavorable weather, germination was slow and the smutted seedlings were first found upon June 8th, and in abundance; but only in the belt where the soil had received the earth from the far away old onion field. A white variety "Pearl" and a red variety "Red Weathersfield" were in alternate rows, and there seemed to be no difference in susceptibility between the two kinds. No smutted onions were found outside of the belt under treatment, which indicates that the disease does not spread rapidly over the field unless the soil is transported, which may be by implements of culture, by winds or the flow of water over the surface of the soil. It is demonstrated that the smut germs can be artificially transferred, very effectively, in small amounts of soil and onion growers should bear the fact in mind in contending with this serious enemy.

The Beet Leaf Blight as a Test for Fungicides.—The beet has been grown in the Experiment Area for the past five years, and is found with us to be one of the best plants for testing of fungicides. There are two fungous diseases that infest the foliage in particular and one of these, *Cercospora beticola* Sacc., is so abundant as to be

safely counted upon as being present. The beet plant is a quick growing annual that lends itself especially well to plot experiments; it is low-growing, a habit of considerable importance in spraying; the leaves are large and the disease is conspicuous. Use has been made of nearly all of the full list of the more common vegetables and vegetable-fruit plants and none of them are equal to the beet as a subject for testing the application of fungicides.

During 1894, the first year that beets were grown upon the Experiment Area, only Mangel wurzels were grown and the Bordeaux mixture gave an increase over the check of 26 per cent. In 1896 four kinds of Bordeaux, namely, the ordinary sort made with lime was used as a standard with which was compared three other kinds, namely, soda-bordeaux, potash-bordeaux and ammonia-bordeaux, the lime being replaced with other alkalies, soda, potash and ammonia respectively. In this year the increase in crop accredited to the Bordeaux mixture was 46.5 per cent. for the roots and 77.5 per cent. for the foliage and these were exceeded by the potash-bordeaux which gave 47.5 per cent. gain in roots and 78.5 per cent. of leaves.

In 1897 five varieties of beets were grown in order to study the susceptibility of the different sorts to the blight and the relative effects the various fungicides might have upon them. Out of this list the three following were selected for further use, namely, "Long blood-red," "Swiss chard" and "Long Mangel wurzel" as representing three widely separated types of beets. In passing it may be mentioned that the "Swiss chard" is a form of beet producing small roots and a large development of leaves with broad etiolated petioles that become the edible portion of the plant. This variety blights badly and becomes a better test of the value of a fungicide than beets of the ordinary sort where the root-weight is the deciding point. In short, the experience of the five years in finding the most suitable plant upon which to experiment with fungicides has led gradually to the acceptance of the beets and of these the "Swiss chard" is the one of greatest value.

During 1898, the "Chard" in the belts sprayed with Bordeaux and the soda-bordeaux were conspicuous for their comparative freedom from blight and the latter was somewhat ahead of the Bordeaux mixture. This soda-bordeaux is made accord-

ing to the following formula: soda, 1 pound (a pound can of Lewis' Lye, for example); copper sulphate, 3 pounds; lime, 5 ounces; water, 30 gallons.

In order to prevent the mixture turning brown (which does not, however, lessen its efficiency but discolors the treated plant) a small quantity of lime is used to neutralize any excess of acid and in this way a permanent bluish-colored solution is obtained. The advantage claimed for this combination is the absence of the large amount of the lime in the ordinary Bordeaux mixture, and it may prove of considerable value in spraying in the fruit garden and vineyard, in particular when the fruit is nearing full size and a clear fungicide does not leave a serious stain upon the fruit. The ease with which the compound may be made and the absence of any danger of clogging the spraying machine commend the mixture to the practical mind.

Susceptibility of Bush Beans to Blight.—Four varieties of bush beans were under experimentation the present season, namely the "Green Flagolet," "Golden Wax," "Early Refugee" and "Saddleback Wax." Two plots were employed, one of them having been in beans continuously since the spring of 1894, two crops each year, and therefore the present season produced the ninth and tenth successive crops. The other plot was of land that had not been in beans for many years, if ever before. Upon the old land the "Refugee" proved the most productive and the "Flagolet" the least, but in spotted pods the results were reversed.

The new land carried a duplicate of the experiment of the one upon the old land, and here the "Refugee" proved the most productive and least susceptible to the disease. If one were seeking a variety to furnish an abundance of disease, for experimental purposes, he could scarcely go amiss in selecting the "Flagolet," while, on the other hand, the "Refugee" would be less acceptable. In foliage the "Flagolet" is exceedingly tender, and from the time the first true leaf appears there is more or less blight in sight.

With the second or autumn crop the same record is made, namely that the "Flagolet" leads all other varieties in susceptibility to the blight. From this and the experience of other years this sort may be considered as one of weak resistant power.

Sweet Corn Smut and Bacterial Disease.—Several varieties of

sweet corn were grown, only one of which has shown unmistakable signs of the bacterial disease (*Pseudomonas Stewarti* E. F. Smith), namely, "First of all." This is a very small form, the chief merit of which is its earliness. A second crop grown with the stubble of the first had some of the plants decay away at the base, due to the bacteriosis.

Smut (*Ustilago maydis* DC.) was quite abundant upon the same variety, and like the *Pseudomonas* was rarely met with elsewhere in the plot where four other varieties of sweet corn were grown.

Rotation of Crops a valuable Fungicide.—The fairly well known fact stated in the headline was brought strikingly to the attention of the writer in an experiment with egg-plants. One plot had been in this crop for three successive years, and a half of it was again set to egg-plants for 1898. A duplicate set of plants was placed upon a half plot of land where that crop probably had never been grown. The treatment as to culture and kinds and times of spraying were the same upon the two areas, and the results are shown in the following table:

New Ground.	Marketable.	Small.	Total.
Sound fruits.	130	80	210
Decayed fruits.	21	19	40
Old Ground.			
Sound fruits.	27	15	42
Decayed fruits.	21	45	66

There were five times as many sound fruits upon the new as upon the old land, while the decayed ones were only 16 per cent. upon the new land and 61 per cent. upon the old land. The point of special interest in this connection was that nine sprayings were made with Bordeaux upon one row of each of the half plots and this mixture was not able to keep the plants in the old land in good health. In short, a crop may be continued so long upon the same land that a fungicide may fail to do its effective work, when a resort to some other crop is the only practical method of dealing with the troubles.

Sulphur as a Remedy for Potato Diseases.—Sulphur was added to five of the twenty-four belts of land in one portion of the Experiment Area devoted to tests for a remedy for the Potato Scab (*Oospora scabies* Thax.).

The following table shows the amounts of sulphur per acre, and the time of application :

Plot	I Belt	2	120 lbs.	1896	480 lbs.	1898	= 600 lbs.	Scab	28.33	%
"	II "	2	240 "	"	240 "	"	480 "	"	31.66	%
"	III "	2	600 "	"			600 "	"	36.66	%
"	III "	6			480 "	"	480 "	"	20.00	%
"	IV "	6	300 "	1895			300 "	"	10.00	%
				Average					25.33	%

All of the "seed" for the whole field, except that of certain check belts, was soaked twice for one hour each in the standard solution of corrosive sublimate and this operation reduced the scab 8½ %. After making this allowance for the corrosive sublimate the sulphur still further reduced the scab from 52 to 25.33 per cent., or to less than half of the average of the unsulphured belts.

In another part of the Experiment Area there were eighteen belts of land in potatoes, and here the three untreated belts gave 63.30 per cent; of scab. There were four belts to which sulphur was added in equal amounts, but at different times, as follows :

	Belt 1.	3	5	6
In 1896.	240 lbs.	480 lbs.		360 lbs.
In 1898	480 "	240 "	720 lbs.	360 "
Total.	720 "	720 "	720 "	720 "

The average percentage of scab upon these four belts is 12.50% or 50.80% below that upon the untreated belts.

One other test was made with sulphur for potato scab, namely in a plot where turnips had been grown for four years continuously, two crops each year, and sulphur at the rate of 1,200 pounds per acre had been added to one belt in 1896.

After an interval of many years since potatoes had been upon this land the scab was abundant, averaging 80% for the five belts not bearing sulphur, while the treated one showed only 35%, and three quarters of this was upon the row adjoining a belt where the scab was recorded as being 90%.

The three above experiments show that in one instance sulphur reduced the amount of scab after the "seed" had been soaked twice in corrosive sublimate from 52% to 25.33%, in the second case from 63.30% to 12.50% and in the last from 80% to 35%. An average of these results shows a reduction of the scab from 65.10% to 24.27%.

A new Tertiary fossil Moss

By Elizabeth G. Britton

The specimen is number 1765 of the National Museum collection. The material in which it was discovered was obtained by Professor I. C. Russell at a coal mine one mile west of Cle Elum, Kittitass Co., Washington, on July 7, 1897. It came from what is known as the "Roslyn sandstone," and its age is probably lower Miocene or upper Eocene. It was sent with other specimens from the same place to Professor F. H. Knowlton, who supplied the facts given above and who states that it is associated with species of *Lygodium*, *Ulmus*, *Planera* and *Chrysophyllum*, besides a number of other beautifully preserved leaves. He recognized it as a fossil moss and states that it is undoubtedly the oldest fossil species thus far found in this country. He submitted it to me for the determination of its nearest living alliance and Dr. Hollick has searched over the literature of fossil mosses and made the drawing of the specimen. I have dedicated the species to its discoverer.

Rhynchostegium Knowltoni

Stem 1 cm. or more long, showing as a carbonized line at several points and seemingly continuous with a slender, curved, carbonaceous prolongation from its apex, like a leafless stolon. Leaves about 1 mm. long, one third as broad, becoming smaller toward the apex of the stem, more or less two-ranked or flattened, spreading at an angle of 45°, not crowded nor overlapping, unequal at base, the upper half of the leaf rounded at base and covering the stem, the lower narrower and tapering to the stem; vein indicated or suggested more or less clearly in the lower leaves by carbonaceous lines continuous beyond the middle of the leaf, disappearing below the apex which is acute but somewhat blunt, in some leaves quite rounded and broad, not tapering.

Evidently belonging to the Hypnaceae with flattened, apparently two-ranked leaves, suggesting by its tapering, stoloniferous stems, a species related to *Rhynchostegium rusciforme* (Neck.)

Br. & Sch., but differing from that species in its more flattened, less crowded leaves and more slender stems. The species of *Rhynchostegium* are rock mosses with creeping, rooting stems, often stoloniferous and bearing the leaves flattened, ovate or lanceolate and in several species blunt or rounded at apex. The vein is single and extends from one half to three fourths the length of the leaf and the base is either narrow or somewhat decurrent. This fossil species has therefore all the essential characters of the genus, though differing somewhat from all living species.

Dr. Hollick has supplied the following notes: Mosses as fossils are exceedingly rare and as far as I am aware, all the species thus far recorded, with one exception are barren. They are almost confined to the Tertiary and later rocks, although Heer supposed that mosses must have been present in the Jurassic period, on account of the presence, in rocks of the Liassic epoch, of the insect genus *Byrrhidium*, whose living representatives feed upon mosses (Primeval World of Switzerland, English edition, Vol. I., p. 89); and Renault and Zeiller have described, and provisionally referred to the mosses, certain remains from the coal measures of Commentry (Comp. Rend. Acad. Sci. Paris, **100**: 660. 1885). Their presence as early as the Carboniferous period is certainly to be expected, as the Pteridophyta and even the Gymnospermae had appeared upon the scene prior to that time, and their absence from the palaeontological record is probably to be accounted for by reason of their insignificant size and the difficulty of their preservation. Fossil mosses were formerly all included under the genus *Muscites* Brong. and under this genus Unger enumerates nine species. (Genera et Species Plantarum Fossilium, 41, 42. 1850). Schimper in his Traité de Paléontologie Végétale, Vol. I., published in 1869, enumerates about thirty species and includes them all, with the exception of three, in living genera and in some cases refers them to living species. A number have been discovered

recently in the Old World in deposits of late geological horizons and referable definitely or provisionally to living species.

The only fossil moss with capsules, which I have been able to find recorded is *Gymnostomum ferrugineum* Ludwig (Palaeont. **8**: 165. *pl. 63, f. 9, 9a.* 1859–61) found in the brown hematite Tertiary deposits of Montabauer. The specimen shows six detached capsules and a few fragmentary branches. Schimper in his Traité de Paléontologie Végétale refers this specimen to the peat mosses and describes it as *Sphagnum Ludwigii*, stating that it is related to *S. cymbifolium* and *S. subsecundum.*

Thus far the only species recorded from America are *Hypnum Hayderi* Lesq., from the Eocene of Colorado (Hayden's Ann. Rept. 1874: 309. 1876; Tert. Fl. **44**: *pl. 5. f. 14–14b*), which is almost certainly a *Lycopodium*, and few fragmentary remains of living species from the Pleistocene deposits of Canada, described by Dawson and Penhallow (Bull. Geol. Soc. Am. **1**: 315, 332. 1890). The specimen now described, is therefore probably the first extinct species and the oldest fossil species recorded from America.

The Washington Botanical Club.

The Washington Botanical Club was organized by a gathering of botanists held at the residence of one of its members, November 11, 1898. The limit of membership was fixed at twenty, and it was determined that the meetings should be for the present, at least, of a distinctly social and informal nature, with free scope for discussion and the general interchange of ideas. At a subsequent meeting held December 14th, the organization was perfected by the election of Professor Edward L. Greene as President and Mr. Charles Louis Pollard as Secretary. The Club is to hold monthly sessions, devoting itself chiefly to systematic and ecological work, the field of physiology and vegetable pathology being covered by the already existing Botanical Seminar. At the December meeting the following resolutions, commemorative of the late Gilbert H. Hicks were unanimously adopted and ordered printed in the leading botanical journals of the country.

"It is with extreme sorrow and heartfelt regret that we learn of the death of our friend and colleague, Mr. Gilbert H. Hicks. To all of us he was known intimately as an earnest co-worker in the field of science and a genial member of our social organizations. His energy, earnestness and conscientiousness in scientific work commanded our approval, and secured recognition for him in all scientific circles as an able investigator. He had already done much to advance knowledge in his chosen line of work, and we feel that the cause of science has lost greatly by his untimely death.

"Much of his work, though of a high scientific character, had been so directed as to yield results of the greatest practical value in the production of food crops, and was intended to lighten, in some degree, the burden of struggling humanity. As a botanist, his keen appreciation of practical problems and his extensive knowledge of plant life well fitted him for this work for the people, and not only science has lost by his death, but all tillers of the soil, those who plow, sow and reap, have lost a true friend and counsellor.

"Yet to us, his daily associates, the loss is greatest. We shall miss his cheery greetings, his companionship, his counsel. It is thus with feeling of deepest sorrow and regret that we have learned that he has been taken from us, while yet in the prime and vigor of early manhood. To his sorrowing family we desire to express our heartfelt sympathy and condolence. We realize how inexpressibly great the loss has been to them, and we mourn with them.

"*Resolved*, That a copy of the above resolutions be sent to the family of the deceased and to the principal botanical magazines in this country."

CHARLES LOUIS POLLARD,
Secretary Washington Botanical Club.

Index to recent Literature relating to American Botany.

Blanc, L., & Decrock, E. Distribution Géographique des Primulacées. Bull. Herb. Boissier, **6**: 681–696. *pl. 17, 18.* Au. 1898; 697–713. S. 1898.

Bohlin, K. Studier öfver några slägten af Alggruppen Confervales Borzi. Bihang. Svens. Vet.-Akad. Handl. **23**[3]: 1–56. *pl. 1, 2.* 1897.

Bohlin, K. Die Algen der ersten Regnell'schen Expedition. I. Protococcoideen. Bihang. Svens. Vet.-Akad. Handl. **23**[7]: 1–47. *pl. 1, 2.* 1897.

Britten, J. *Botrychium australe* Br. Jour. Bot. **36**: 491. D. 1898.

Burkill, I. H. Changes in the sex of Willows. Ann. Bot. **12**: 557, 558. D. 1898.

Christ, H. Filices Novae. Bull. Herb. Boissier, **6**: 835–837. O. 1898.

Polypodium Schnittspalmii from Andes among other old world species.

Christ, H. Fougères recueillies dans le bassin inférieure de l'Amazone par le Dr. J. Huber à Para. Bull. Herb. Boissier, **6**: 991–994. 26 D. 1898.

New species in *Trichomanes* and *Polypodium*.

Clute, W. N. The Cleistogamous Flowers in the Genus *Viola*. Plant World, **2**: 47, 48. D. 1898.

Clute, W. N. Spring in the Shinnecock Hills. Plant World, **2**: 53–55. Ja. 1899.

Coville, F. V. The Fairy-ring Mushroom. Plant World, **2**: 39–41. *f. 1–3.* D. 1898.

Crepin, F. Observations sur le *Rosa stellata* Wooton. Bull. Herb. Boissier, **6**: 725–728. S. 1898.

Debski, B. Weitere Beobachtungen an *Chara fragilis* Desv. Jahrb. wiss. Bot. **32**: 635–670. *pl. 11, 12.* 1898.

De Candolle, C. Piperaceae Sodiroanae. Bull. Herb. Boissier, **6**: 475–495. Je. 1898; 505–521. Jl. 1898.

Many new species collected in Ecuador by Sodiro.

Dietel, P. Einige Brandpilze aus Südamerika. Hedwigia (Beiblatt) **37**: 147–149. 25 O. 1898.

New species in *Ustilago*.

Eastwood, A. Notes on the Flora of Marin County [California]. II. Erythea, **6**: 117, 118. 15 D. 1898.

Eaton, A. A. A new Species of *Botrychium*. Fern Bull. **7**: 7, 8. Ja. 1898.

B. tenebrosum sp. nov.

Eggleston, W. W. Some rare Vermont Ferns. Fern Bull. **7**: 4, 5. Ja. 1898.

Ellis, W. G. P. A Method of obtaining Material for illustrating Smut in Barley. Ann. Bot. **12**: 566, 567. D. 1898.

Errera, L. Structure of the Yeast-Cell. Ann. Bot. **12**: 567, 568. D. 1898.

Ganong, W. F. Contributions to a Knowledge of the Morphology and Ecology of the Cactaceae: II. The Comparative Morphology of the Embryos and Seedlings. Ann. Bot. **12**: 423–474. *pl. 26.* D. 1898.

Gilbert, B. D. *Dryopteris Noveboracensis* without Indusia. Fern Bull. **7**: 3. Ja. 1898.

Green, J. R. The Alcohol-producing Enzyme of Yeast. Ann. Bot. **12**: 491–497. D. 1898.

Greene, E. L. Wisconsin Field Notes. Plant World, **2**: 37, 38. D. 1898.

Grout, A. J. Some floral Monstrosities. Plant World, **2**: 64. Ja. 1899.

Hallier, H. Bausteine zu einer Monographie der Convolvulaceen. Bull. Herb. Boissier, **5**: 1021–1052. D. 1897; **6**: 714–724. S. 1898.

Halsted, B. D. Partial Sterility of fertile *Woodwardia* Fronds. Plant World, **2**: 55, 56. Ja. 1899.

Hartog, M. Alternation of Generations. Ann. Bot. **12**: 593, 594. D. 1898.

Huie, L. H. Changes in the Gland-Cells of *Drosera* produced by various Food-materials. Ann. Bot. **12**: 560, 561. D. 1898.

Ikeno, S. Untersuchungen über die Entwickelung der Geschlectorgane und den Vorgang der Befruchtung bei *Cycas revoluta*. Jahrb. wiss. Bot. **32**: 557–602. *pl. 8–10.* 1898.

Janczewski, E. de. Études morphologiques sur le genre *Anemone* L. Rev. Gen. Bot. **10**: 433–446. 15 N. 1898.

Jeffrey, E. C. The Gametophyte of *Botrychium Virginianum*. Trans. Canadian Inst. **5**: —(1–32). *pl 1–3.* 1898.

Jones, C. E. The Anatomy of the Stem of Species of *Lycopodium*. Ann. Bot. **12**: 558, 559. D. 1898.

Juel, H. O. Die Ustilagineen und Uredineen der ersten Regnell' schen Expedition. Bihang. Svens. Vet.-Akad. Handl. **23**[10]: 1–30. *pl. 1–4*. 1897.

Chaconia and *Leptinia* nov. gen. New species in *Puccinia*, *Aecidium* and *Uredo*.

Keller, R. Ueber die central- und südamerikanichen *Hyperica* des Herbarium Hauniense. Bull. Herb. Boissier, **6**: 253–268. S. 1898.

Klebs, G. Alternation of Generations in the Thallophytes. Ann. Bot. **12**: 570–583. D. 1898.

Lang, W. H. Alternation of Generations in the Archegoniatae. Ann. Bot. **12**: 583–592. D. 1898.

Lind, K. Ueber das Eindringen von Pilzen in Kalkgesteine und Knochen. Jahrb. wiss. Bot. **32**: 603–634. 1898.

Lloyd, J. U. *Laurus Sassafras*. Pharmaceutical Review, **16**: 450–459. D. 1898.

Macoun, J. M. Contributions to Canadian Botany, XII. Ottawa Nat. **12**: 161–172. D. 1898.

Malme, G. O. A: N. Die Flechten der ersten Regnell'schen Expedition. I. Die Gattung Pyxine. Bihang. Svens. Vet.-Akad. Handl. **23**[18]: 1–52. 1897.

P. corallifera and *P. obscurascens* new.

Maxon, W. R. Young Hart's Tongues at Green Lake. Fern Bull. **7**: 1, 2. Ja. 1899.

Meehan, T., Editor. *Liatris odoratissima*. Meehan's Monthly, **8**: 177, 178. D. 1898.

Merriam, C. H. Life Zones and Crop Zones of the United States. Bull. U. S. Dept. Agric. (Biol. Survey) **10**: 1–73. 1898. [Illust.]

Moser, J., & Hay, G. U. List of Mosses of New Brunswick. Bull. Nat. Hist. Soc. N. B. **16**: 23–31. 1898.

Nathansohn, A. Beiträge zur Kenntniss des Wachsthums der trachealen Elemente. Jahrb. wiss. Bot. **32**: 671–686. *pl. 13*. 1898.

Orton, W. A. A partial List of the parasitic Fungi of Vermont. Ann. Rep. Vt. Agric. Exper. Station, **11**: — (1–21). S. 1898.

Otis, D. H. Root Tubercles and their Production by Inoculation. Industrialist, **24**: 363–378, *pl. 17*. Je. 1898.

Pammel, L. H. Old Lake Vegetation in Hamilton County, Iowa. Plant World, **2**: 42–45. D. 1898. [Illust.]

Plank, E. N. Concerning the Plants of Southwestern Arkansas. Plant World, **2**: 45–47. D. 1898.

Plumb, C. S. The geographic Distribution of Cereals in North America. Bull. U. S. Dept. Agric. (Biol. Survey) **11**: 1–22. *f. 3.* 1898.

Rothrock, J. T. Honey Locust. [*Gleditschia triacanthos* L.] Forest Leaves, **6**: 201. D. 1898.

Saunders, De A. Phycological Memoirs. Proc. Cal. Acad. Sci. Bot., III., **1**: 147–168. *pl. 12–32.* 31 O. 1898.

Contains descriptions of "Some Pacific Coast Ectocarpaceae" of the "Sphacelariaceae and Encoeliaceae of the Pacific Coast; new species, varieties and forms in *Ectocarpus, Pylaiella, Sphacelaria, Scytosiphon* and *Colpomenia; Halorhipis*, gen. nov.

Schrenk, H. von. On the Mode of Dissemination of *Usnea barbata.* Trans. Acad. Sci. St. Louis, **8**: 189–198. *pl. 16.* 17 D. 1898.

Schumann, K. Ueber *Opuntia tunicata* Lk. et Otto. Monatsschrift für Kakteenkunde, **8**: 154–156. 15 O. 1898.

Shaw, W. R. Ueber die Blepharoplasten bei *Onoclea* und *Marsilia.* Ber. deutsch. Bot. Ges. 16: 177–184. *pl. 11.* 10 S. 1898.

Smith, E. F. Notes on Stewart's sweet-corn germ, *Pseudomonas Stewartii* n. sp. Proc. A. A. A. S. **47**: 422–426. D. 1898.

Smith, J. Donnell. Primitiae Florae Costaricensis. (Polypetalae.) **21**: 1–126. 1898.

Solereder, H. *Buddleia Geisseana* R. A. Philippi, eine neue *Lippia* Art. Bull. Herb. Boissier, **6**: 623–629. Jl. 1898.

Stephani, F. Die Lebermoose der ersten Regnell'schen Expedition nach Sudamerika. Bihang. Svens. Vet. Akad. Handl. **23**^{2}; 1–36. 1897.

New species in *Anthoceros, Fimbriaria, Frullania, Lejeunea, Nardia, Riccia* and *Ricciella.*

Stephani, F. Species Hepaticarum. Bull. Herb. Boissier, **6**: 757–799. O. 1898.

Completes Ricciaceae and describes lower forms of Marchantiaceae.

Stevens, W. C. The Behavior of Kinoplasm and Nucleolus in the Division of the Pollen Mother Cells of *Asclepias Cornuti.* Kan. Univ. Quart. **7**: 77–85. *pl. 5.* Ap. 1898.

Suksdorf, W. N. Washingtonische Pflanzen. Deutsche Bot. Monats. **16**: 209–212. N. 1898.

New species in *Delphinium, Nasturtium, Arabis* and *Silene.*

Svedelius, N. Die Juncaceen der ersten Regnell'schen Expedition. Bihang. Svens. Vet.-Akad. Handl. **23**^{6}: 1–11. *pl.* 1897.

Tilden, J. E. The Study of the Algae. Plant World, **1**: 148–150. *f. 1–3.* Jl. 1898.

Tilden, J. E. The Study of Algae in High Schools. Plant World, **2**: 59–63. Ja. 1899.

Tracy, S. M. A Report upon the Forage Plants and Forage Resources of the Gulf States. Bull. U. S. Dept. Agric. (Div. Agrost.) **15**: 1–55. *f. 1–20.* 1898.

True, R. H. Geographical Distribution of *Dicrana*. Fern Bull. **7**: 25–27. Ja. 1898.

True, R. H. Botanizing in the Dales of the Wisconsin River. Plant World, **1**: 81–83. Mr. 1898.

Urban, J. Plantae novae Americanae imprimis Glaziouanae. Bot. Jahrbuch. Beiblatt. **25**: 1–51. 19 Jl. 1898.

New species from Brazil in Rhamnaceae, Turneraceae, Umbelliferae, Buettneriaceae, Bombacaceae, Rutaceae, Asclepiadaceae and other families.

Wager, H. The Nucleus of the Yeast-Plant. Ann. Bot. **12**: 499–543. *pl. 29, 30.* D. 1898.

Ward, H. M. A Potato-Disease. Ann. Bot. **12**: 561–564. D. 1898.

Ward, H. M. *Penicillium* as wood-destroying Fungus. Ann. Bot. **12**: 565, 566. D. 1898.

Ward, L. F. A New Compass Plant. Plant World, **1**: 118. My. 1898.

Waters, C. E. Witches' Broom on the Locust. Plant World, **1**: 83, 84. Mr. 1898.

West, W., and **G. S.** Notes on Freshwater Algae. Journ. Bot. **36**: 330–338. S. 1898.

Tetraedon Floridense sp. nov., from Deland, Florida

White, C. A. Protective Stipules. Plant World, **1**: 106–108. Ap. 1898.

White, C. A. Tuna and its Distribution. Plant World, **1**: 166–168. Au. 1898.

Wieler, A. Die Function der Pneumathoden und des Aërenchyms. Jahrb. wiss. Bot. **32**: 501–524. *pl. 7.* 1898.

Williams, F. N. Énumération provisoire des espèces du genre *Cerastium*. Bull. Herb. Bossier, **6**: 893–904. N. 1898.

[This Index is reprinted each month by the Cambridge Botanical Supply Company in card catalogue form.]

PUBLICATIONS BY OFFICERS AND STUDENTS OF THE DEPARTMENT OF BOTANY, COLUMBIA UNIVERSITY

1. MEMOIRS OF THE DEPARTMENT:

Vol. 1. A Monograph of the North American Species of the Genus *Polygonum* (1895). By John Kunkel Small, Fellow in Botany, 1893–1895; Curator of the Herbarium, 1895–1898.

Quarto, 178 pages, 84 plates. Price $6.00.

Vol. 2. A Monograph of the North American Potentilleae (1898). By Per Axel Rydberg, Fellow in Botany, 1896–7.

Quarto, 224 pages, 112 plates Price $6.00.

2. CONTRIBUTIONS FROM THE DEPARTMENT:

Vol. 1. Nos. 1–25. 1886–1892. Price $5.00.
Vol. 2. Nos. 26–50. 1892–1894. Price $5.00.
Vol. 3. Nos. 51–75. 1894–1895. Price $5.00.
Vol. 4. Nos. 76–100. 1895–1896. Price $5.00.
Vol. 5. Nos. 101–125. 1896–1897. Price $5.00.
Vol. 6. Nos. 126–150. 1897–1898. Price $5.00.
Vol. 7. Nos. 151–(current).

3. A Text-book of General Lichenology (1896). By Albert Schneider, Fellow in Botany, 1895–1896.

Octavo, 230 pages, 76 plates. Price $4.25 (cloth); $3.80 (paper). Published by Willard N. Clute & Co. Binghamton, N. Y.

The Department invites propositions relative to exchanges of herbarium material or botanical books for any of the above named publications. Address Professor L. M. Underwood, Columbia University, N. Y. City. A list of the titles of Contributions with prices of such as can be separately supplied, may be had on application. Many of the earlier numbers are out of print, but a few complete sets can be supplied.

4. An Illustrated Flora of the Northern United States, Canada, and the British Possessions from Newfoundland to the Parallel of the Southern Boundary of Virginia, and from the Atlantic Ocean westward to the 102d Meridian (1896–1898). By Nathaniel Lord Britton, Professor of Botany, 1891–1896; Emeritus Professor 1896,—and Hon. Addison Brown.

Three volumes, royal octavo. Vol. 1, 612 pages; Vol. 2, 642 pages; Vol. 3, 588 pages; 4162 figures in the text, illustrating every species described.

Published by Charles Scribner's Sons, New York. Price, in cloth, $9.00 for the three volumes; with the indexes and keys bound separately, $10.00.

5. Our Native Ferns and their Allies. (Fifth Edition) 1896. By Lucien Marcus Underwood, Professor of Botany, 1896–.

Duodecimo, 156 pages, 35 figures. Published by Henry Holt & Co. New York. Price $1.00.

6. A Text-book of General Botany (1897). By Carlton Clarence Curtis, Assistant in Botany, 1892–1895; Tutor in Botany, 1895–.

Octavo, 360 pages; 87 illustrations. Published by Longmans, Greene & Co. New York. Price $3.00.

WET AND DRY

Cryptogamic and Phaenogamic

PLANT MATERIAL

collected and preserved especially

FOR CLASS STUDY.

Microscopes, Lenses, Cover Glasses and Slides, Forceps, Scalpels and Needles. "Laboratory Note Book" of high grade Drawing Paper with alternate blank and ruled pages. Glassware, Stains, Mounting Paper, etc.

Cambridge Botanical Supply Co.,

CAMBRIDGE, MASS.

Everything Useful to Botanists.

MORE THAN FIFTY OF

AMERICA'S LEADING BOTANISTS

HAVE CONTRIBUTED TO THE FIRST VOLUME OF

THE PLANT WORLD.

It contains 192 pages, upwards of 175 articles and numerous illustrations printed on the best of book paper. Price, $1.00, if ordered now.

Volume II. will be enlarged and improved in many ways. No effort will be spared to make this a journal of interest to every plant lover.

SUBSCRIPTIONS, $1.00 PER ANNUM.

ADDRESS

WILLARD N. CLUTE & CO., Publishers, Binghamton, N. Y.

A Text-Book of General Botany

BY

CARLTON C. CURTIS, A.M., Ph.D.,

Tutor in Botany in Columbia University.

Large Octavo, Cloth. Pp. viii–360. With 87 Illustrations.

Price, $3.00 *net.*

An introdution to the study of Botany with copious direc-ons for laboratory exercises, newly prepared illustrations, their nomenclature following the principles adopted by the Botanical Club of the American Association for the Advancement of Science

LONGMANS, GREEN & CO., New York.